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Popular Science

THE What's New MAGAZINE

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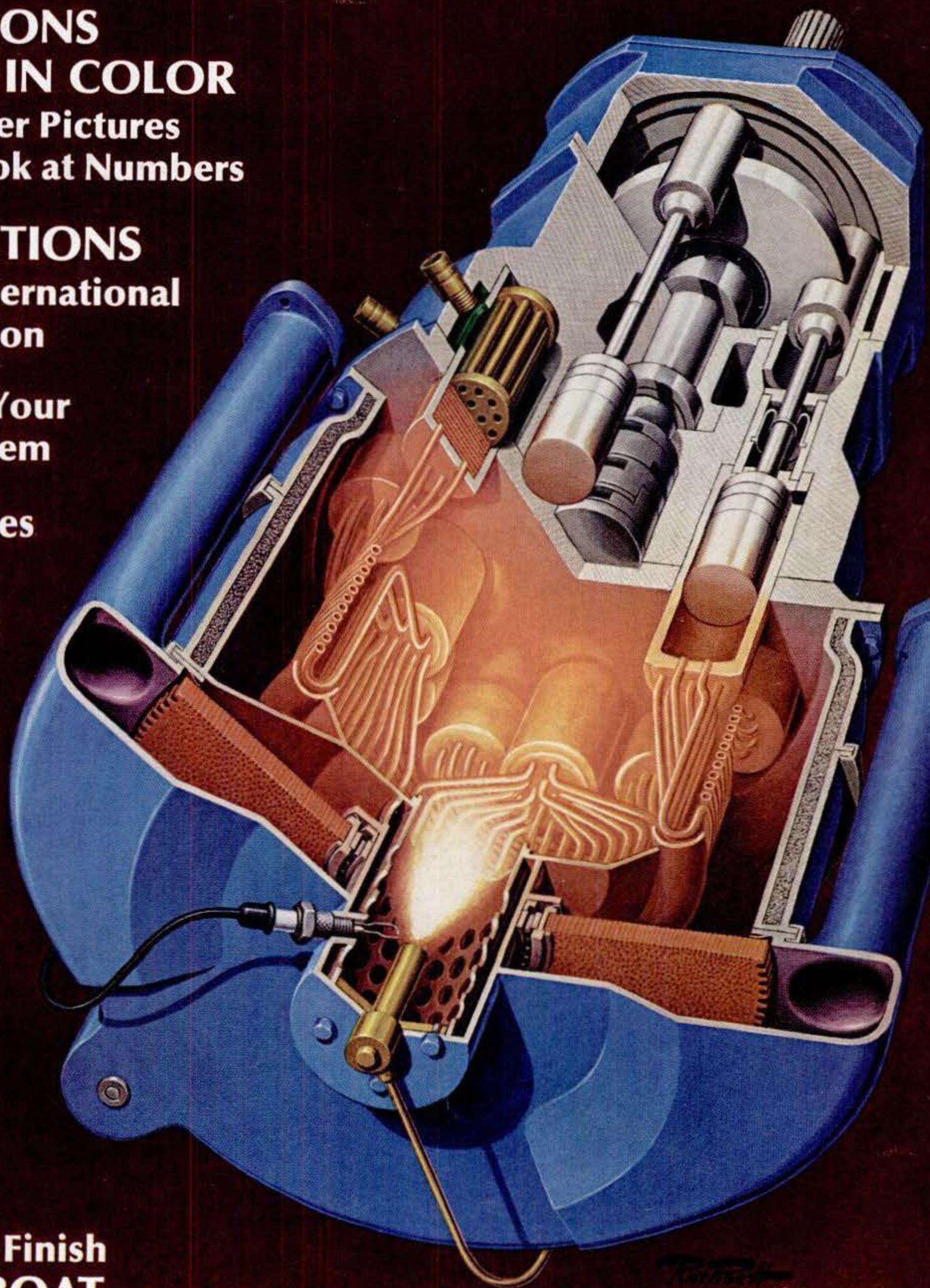

.US 17 other fascinating features—See Contents on page 2

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Chrysler for '73. Engineered to make things easy.

If fishing's not fast enough, and racing's not your speed, Chrysler has a complete choice of mid-range outboards that make it easy to get family plans off the ground.

These Chryslers will let you go the limit from ski to cruise, from wide open to troll. And you've got a pick of power ranging from 20 to 55 horsepower in 16 distinct models.

The brand-new 25 and 30 are high-performance portables that allow you to do a whole lot more with just a little more power.

The Chrysler 35 is the winningest motor in the national APBA powerboat racing. The 55 offers the highest BIA-certified 2-cylinder horsepower anywhere.

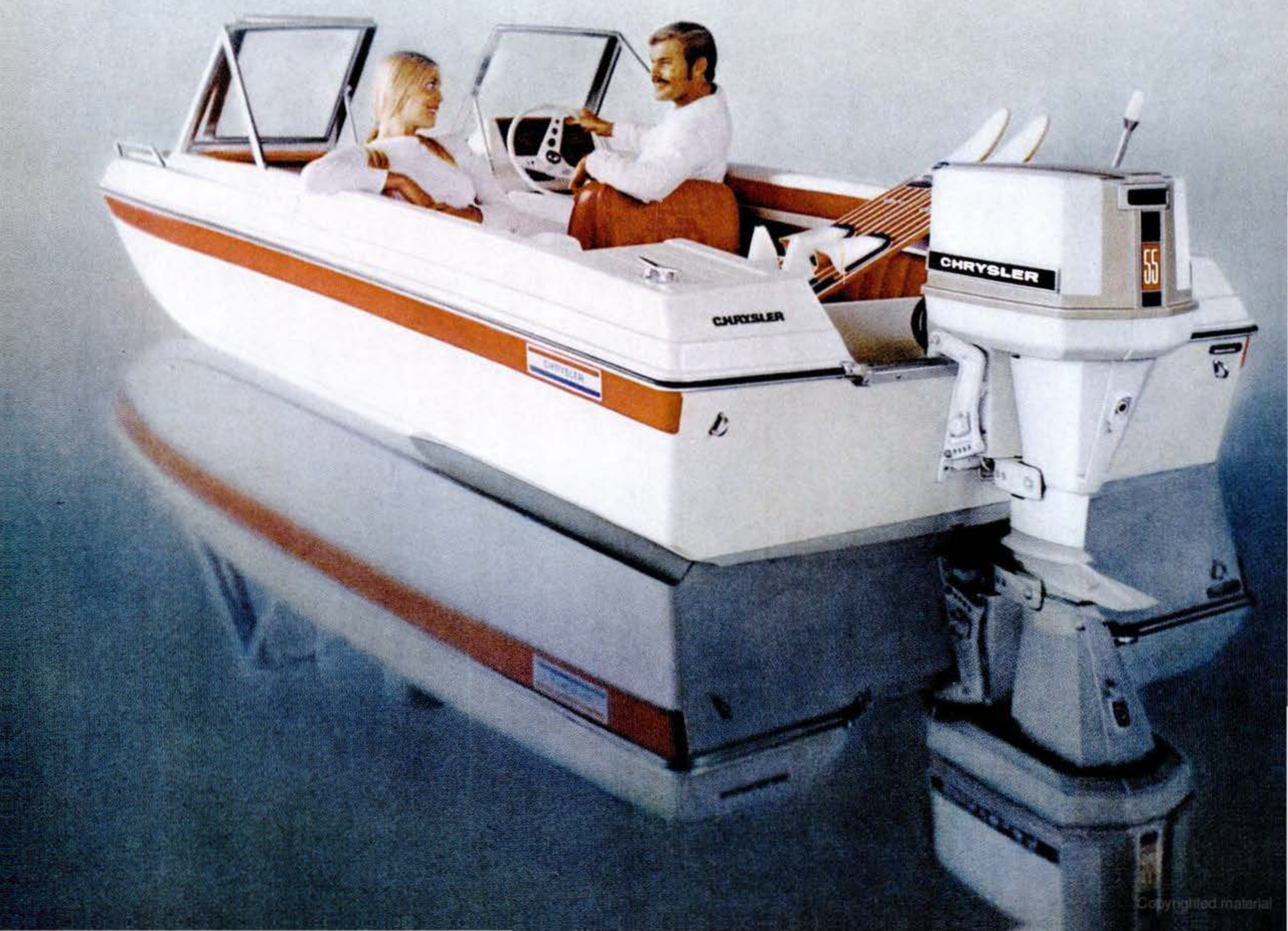
They're all engineered to make life easy with new features like built-in rear handles for easier tilt-up, new upper gear housing for more efficient cooling and integrally designed fuel pump for easier maintenance.

Also, Chrysler outboards are engineered to go easy on the environment with greatly improved silencing, and fuel recycling to keep the water clean.

See your Chrysler Crew Dealer. You'll find him listed in the Yellow Pages. He can provide everything you need except the water. Ask him for your free copy of the Chrysler Boat Buyer's Guide.

MARINE PRODUCTS CHRYSLER CORPORATION

The Chrysler Crew makes things easy for you.



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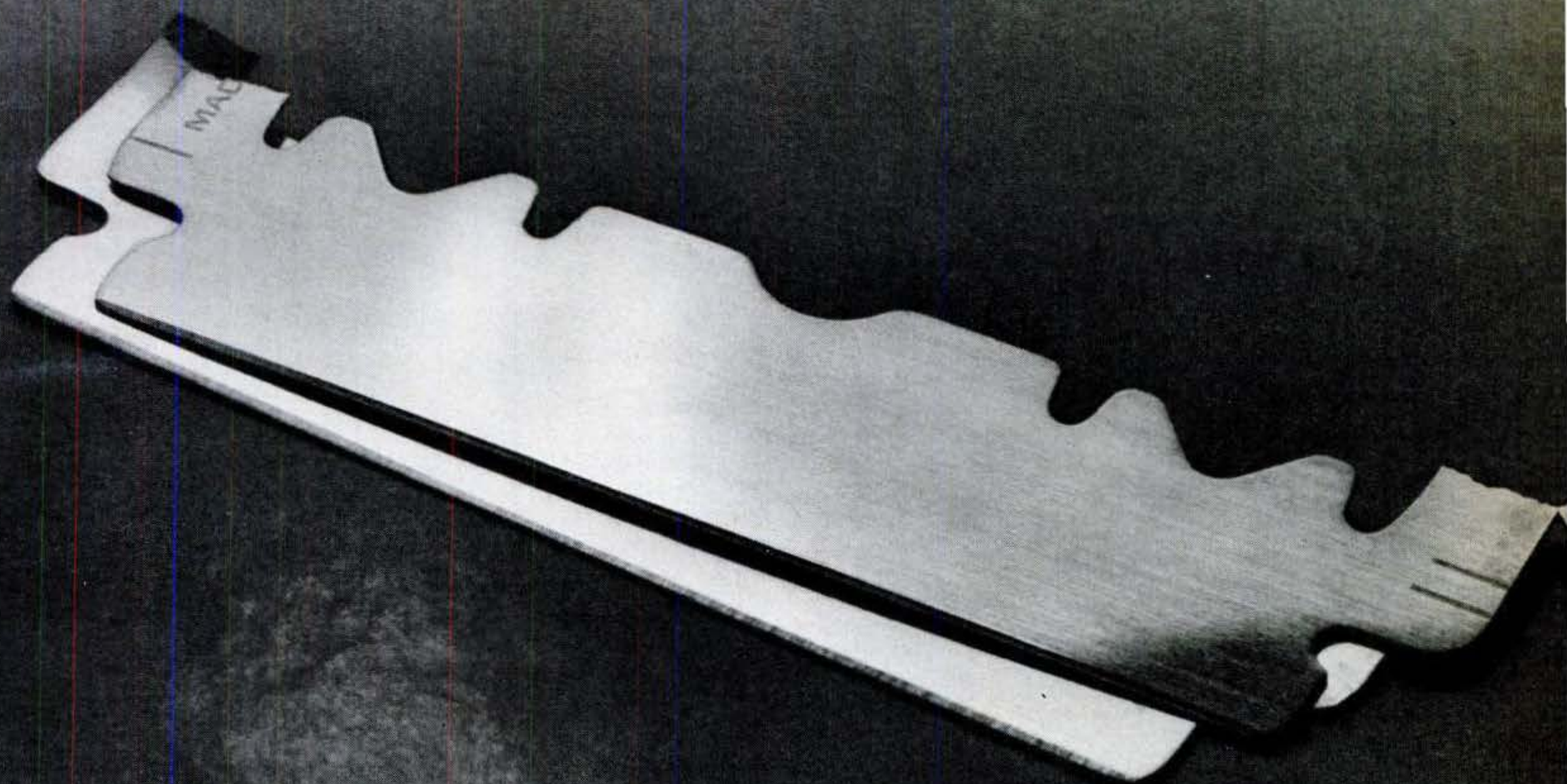

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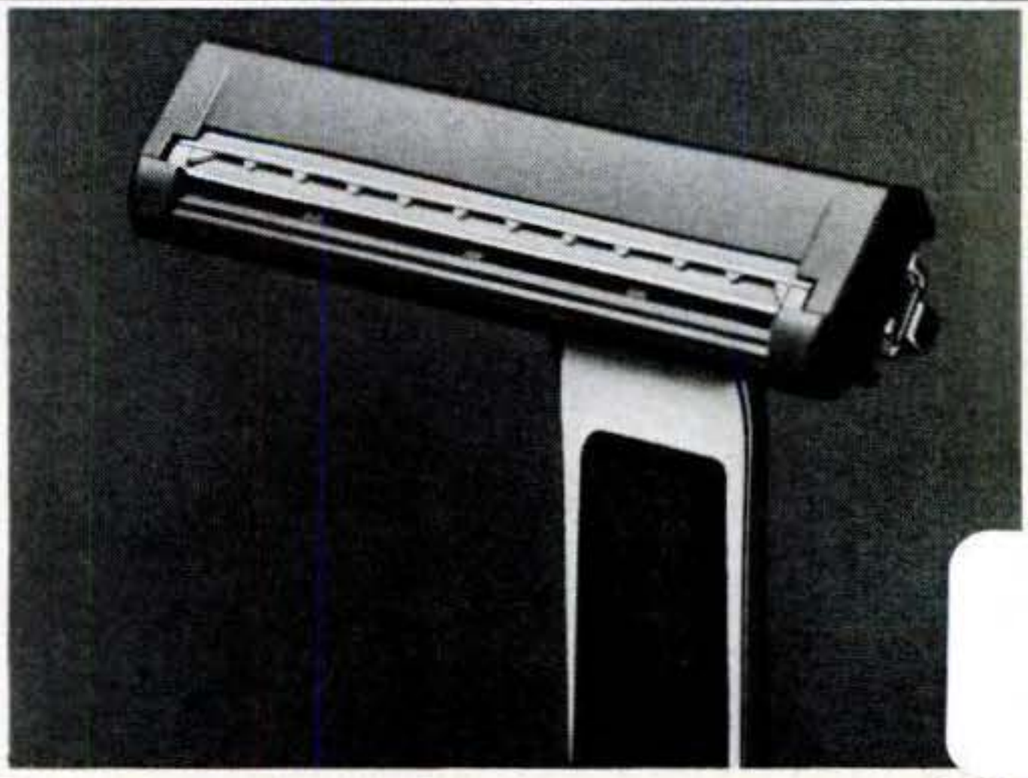
Is tomorrow the morning when you stop to think: What good is a double edge if you can only shave with one edge at a time?

Schick's put both edges on your side. In the Schick Super II twin blade shaving system. With two Super Chromium blades locked in a replaceable cartridge.

What one blade might miss, the other one gets.

The new Schick Super II. It's enough to make you break an old habit.



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EDITORIAL OFFICES
355 Lexington Ave., New York, N. Y. 10017

PUBLISHED MONTHLY By Popular Science Publishing Co., Inc., 355 Lexington Ave., New York, N. Y. 10017.

Microfilm editions are available from University Microfilms, Ann Arbor, Mich. 48106.

ADVERTISING OFFICES
NEW YORK: 355 Lexington Ave. (10017), Tel. 212-687-3000; CHICAGO: 401 N. Michigan Ave. (60611), Tel. 312-527-0550; DETROIT: 1716 Fisher Building (48202), Tel. 313-872-7060; LOS ANGELES (Pacific West Coast): 3550 Wilshire Blvd., Suite 908 (90005), Tel. 213-380-1936.

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Once and for all, American Motors wants you to judge which one of these companies has the best new car guarantee.

THE FOLLOWING PARTS AND SERVICES ARE GUARANTEED AGAINST FACTORY DEFECTS AND REPLACEMENT DUE TO WEAR FOR 12 MONTHS OR 12,000 MILES.

PARTS FIXED OR REPLACED FREE.	AMC	GM	FORD	VW	CHRYSLER
Engine/Drive train	YES	YES	YES	YES	YES
Spark plugs	YES	NO	NO	NO	NO
Points & Condenser	YES	NO	NO	NO	NO
Shock Absorbers	YES	NO	NO	NO	NO
Brake linings	YES	NO	NO	NO	NO
Clutch lining	YES	NO	NO	NO	NO
Wiper blades	YES	NO	NO	NO	NO
Light bulbs	YES	NO	NO	NO	NO
Hoses & Belts	YES	YES	NO	NO	NO
SERVICES PROVIDED FREE.					
Wheel alignment	YES	NO	NO	NO	NO
Wheel balancing	YES	NO	NO	NO	NO
Align headlights	YES	NO	NO	NO	NO
Adjust carburetor	YES	NO	NO	NO	NO
Adjust distributor	YES	NO	NO	NO	NO
Adjust brakes	YES	NO	NO	NO	NO
Adjust clutch	YES	NO	NO	NO	NO
Adjust transmission bands	YES	NO	NO	NO	NO
Adjust & tighten belts	YES	NO	NO	NO	NO
Tighten nuts & bolts	YES	NO	NO	NO	YES
Free loaner car	YES	NO	NO	NO	NO
Trip Interruption Protection	YES	NO	NO	NO	NO

Last year American Motors introduced the Buyer Protection Plan.

Now everyone's trying to get on the bandwagon.

So, once and for all, we'd like to set the record straight. Who does back their cars the best?

Well, notice the proliferation of "NO's" in every one but the American Motors column.

Why a Buyer Protection Plan and not just a guarantee?

Most companies feel that a guarantee is backing enough for a new car.

But American Motors wants to do more.

Item: A simple, strong guarantee.* In fact, the only guarantee that expects every part to last for 12 months or 12,000 miles, or we'll fix it free.

*When you buy a new 1973 car from an American Motors dealer, American Motors Corporation guarantees to you that, except for tires, it will pay for the repair or replacement of any part it supplies that is defective in material or workmanship. This guarantee is good for 12 months from the date the car is first used or 12,000 miles, whichever comes first. All we require is that the car be properly maintained and cared for under normal use and service in the fifty United States or Canada, and that guaranteed repairs or replacement be made by an American Motors dealer.

Item: American Motors is the only manufacturer that has a plan to provide a free loaner car if guaranteed repairs take overnight.

Item: Special Trip Interruption Protection. If your car needs guaranteed repairs more than 100 miles from home, American Motors will pay all reasonable expenses for food and lodging—up to $150.

Item: A free hot line to Detroit. If you want to get mad at us, we'll listen.

Our dealers make it possible for us to run this ad.

No manufacturer's guarantee can be successful without the cooperation of its dealers.

And like us, our dealers' dedication to the Buyer Protection Plan has become a way of life.

They know that we'll back them in their commitment to you, the customer, under the terms of the Buyer Protection Plan.

Besides, they're finding out what we've suspected all along: Build a good strong car with a good strong guarantee and the world will beat a path to your door.

AMC

We back them better because we build them better.

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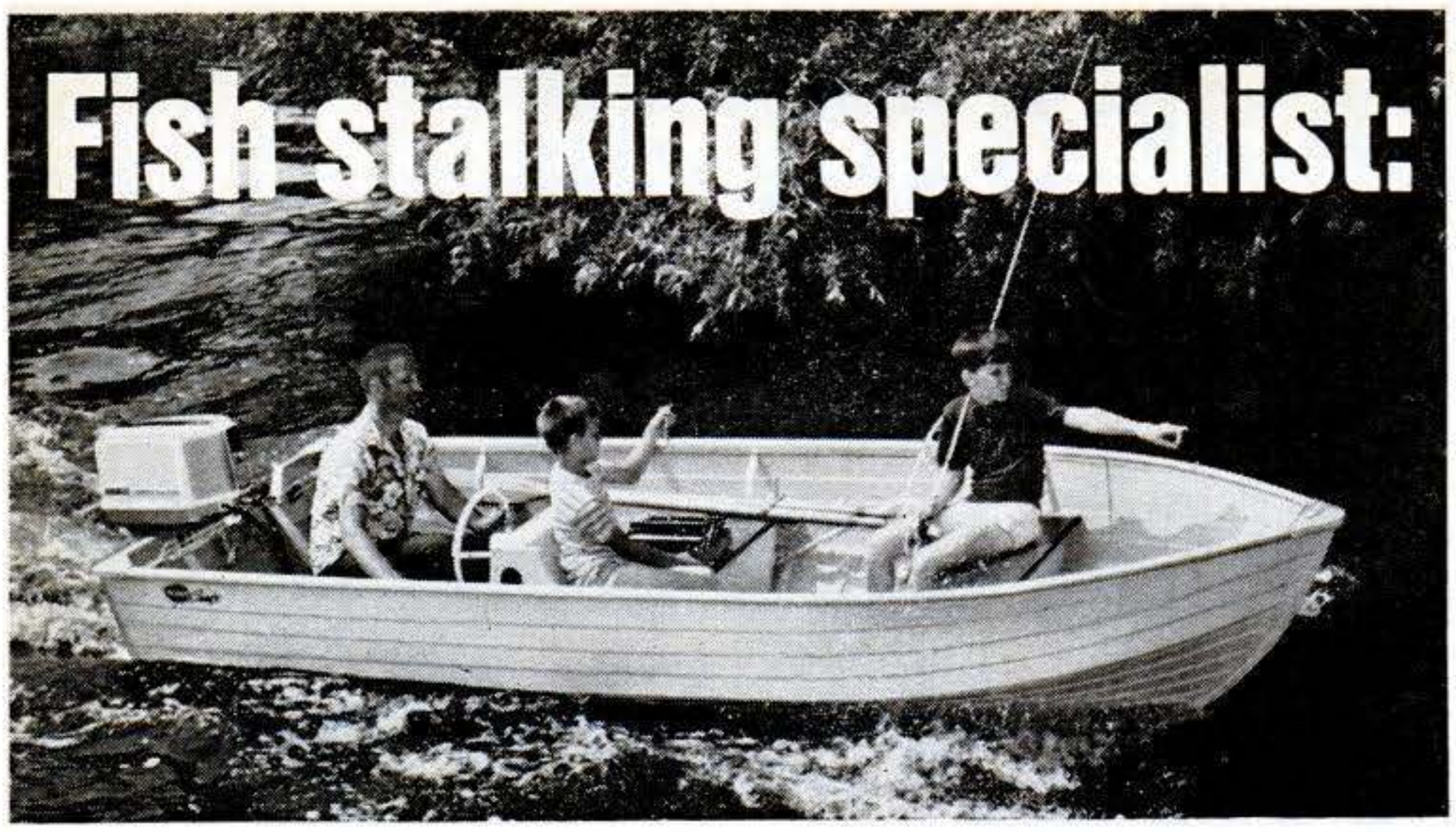

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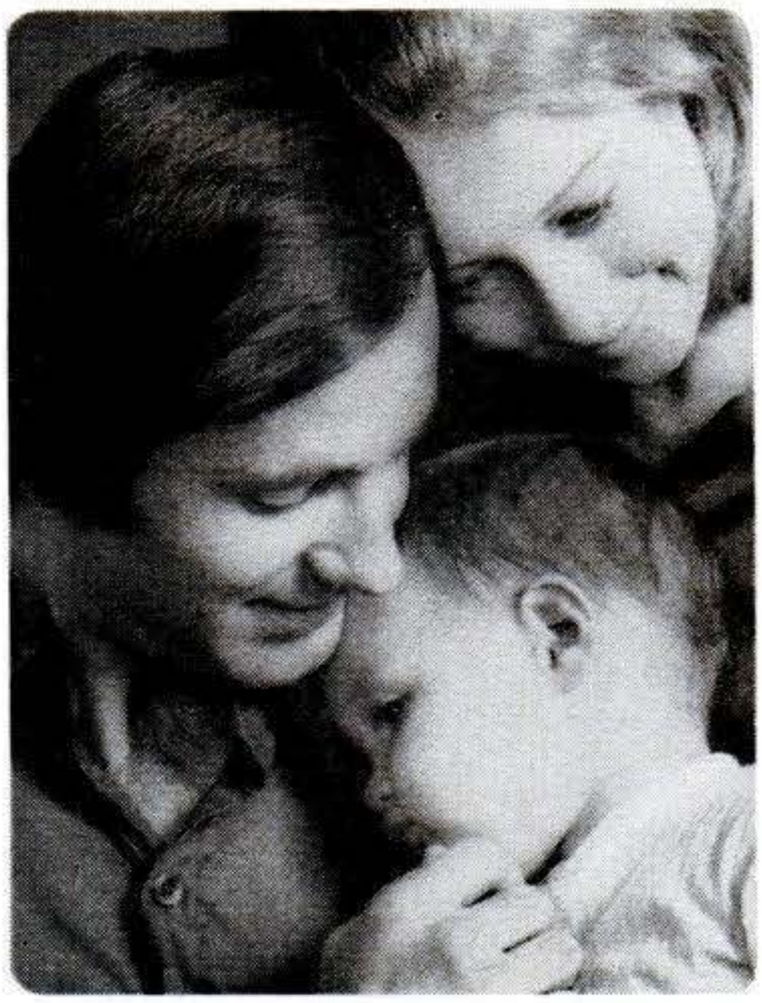

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Troubleshooting Quiz #3: Your Car's Cooling System

FEBRUARY 1973
Vol. 202, No. 2

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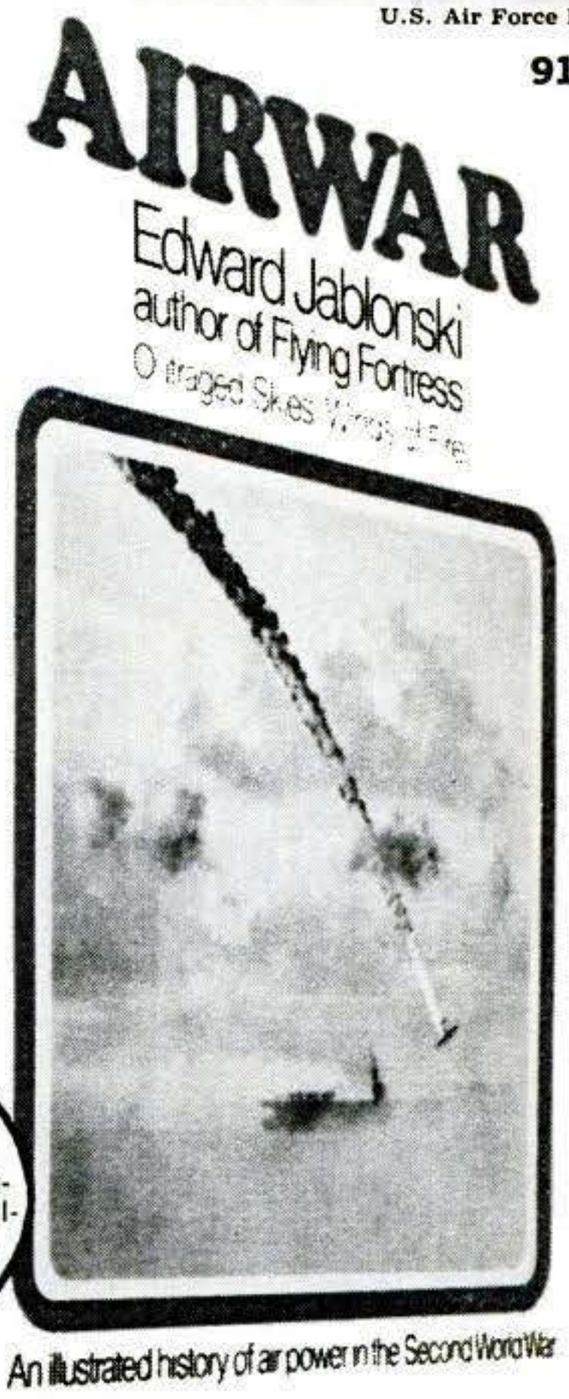

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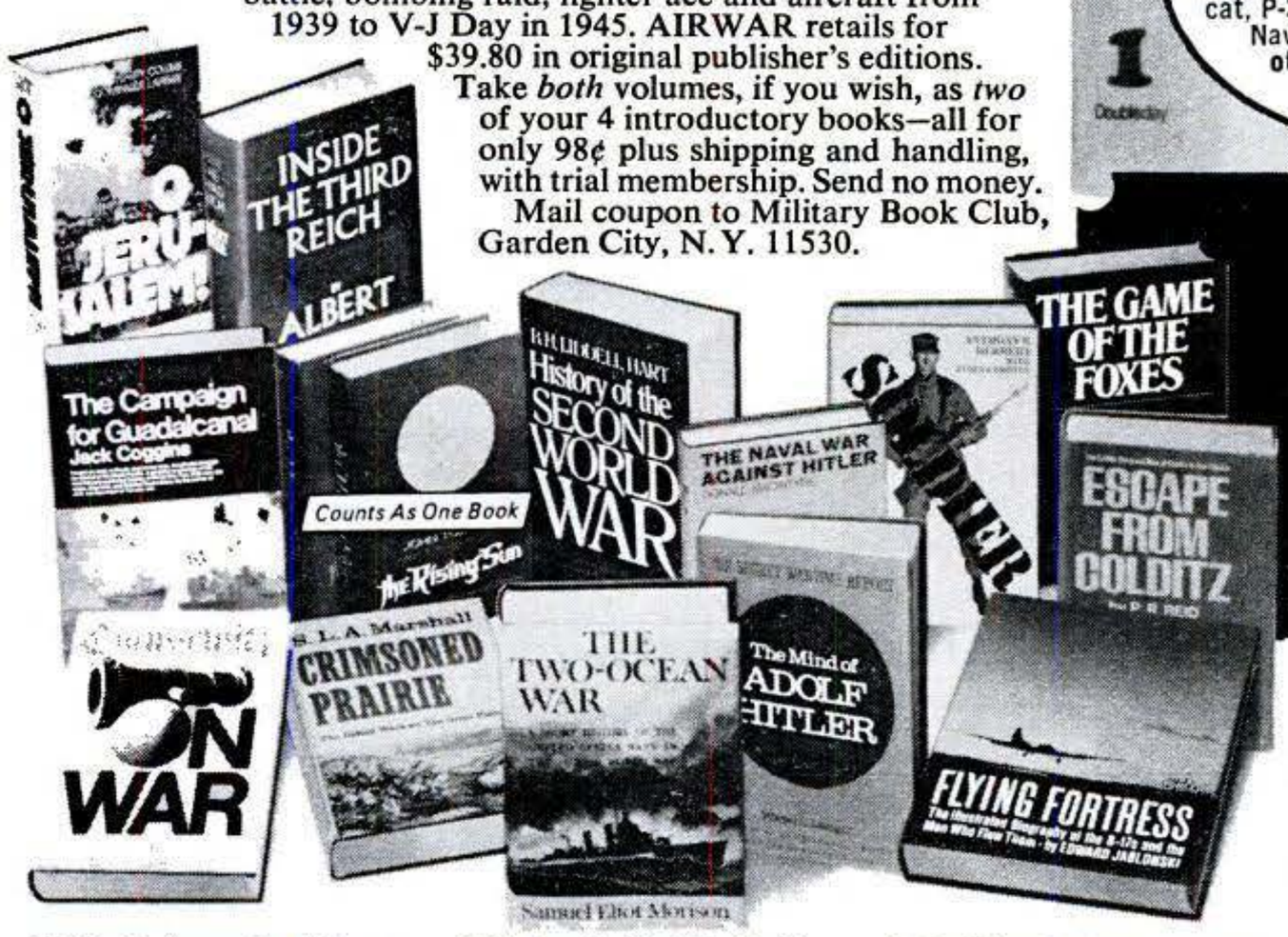

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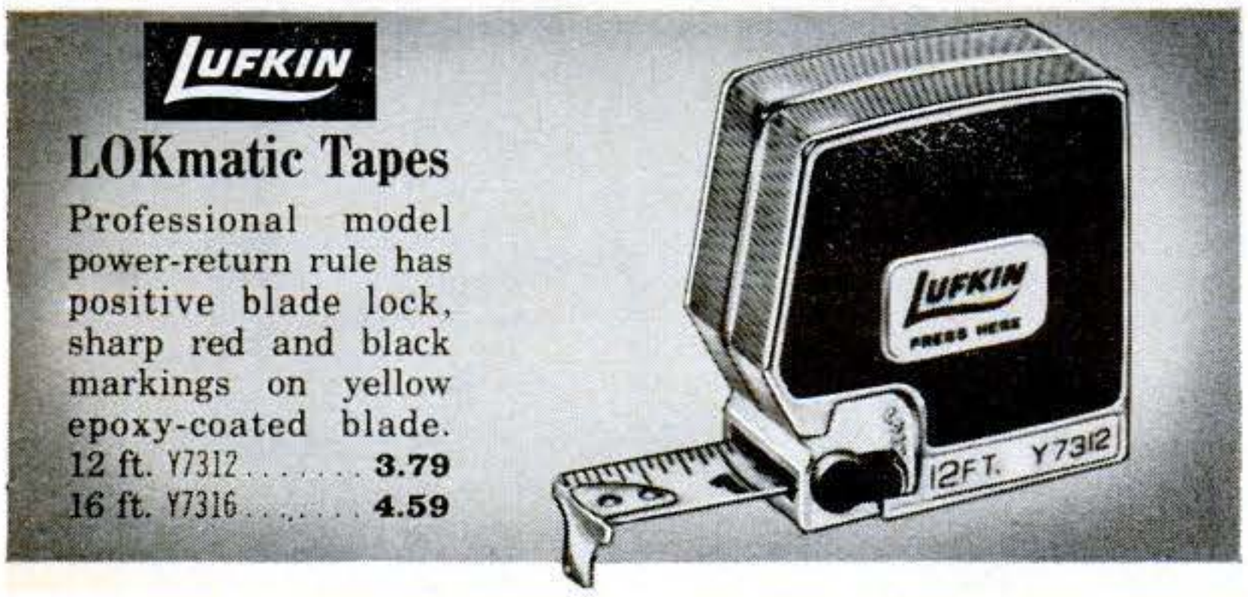

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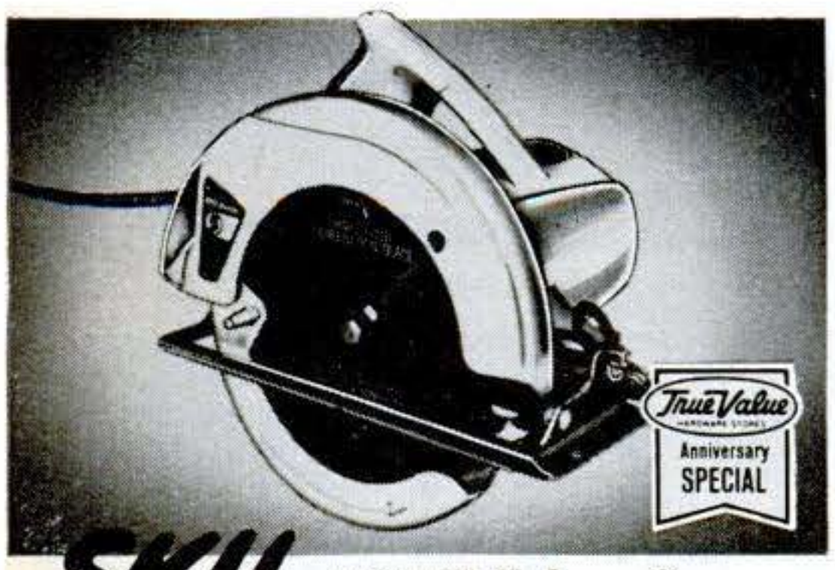

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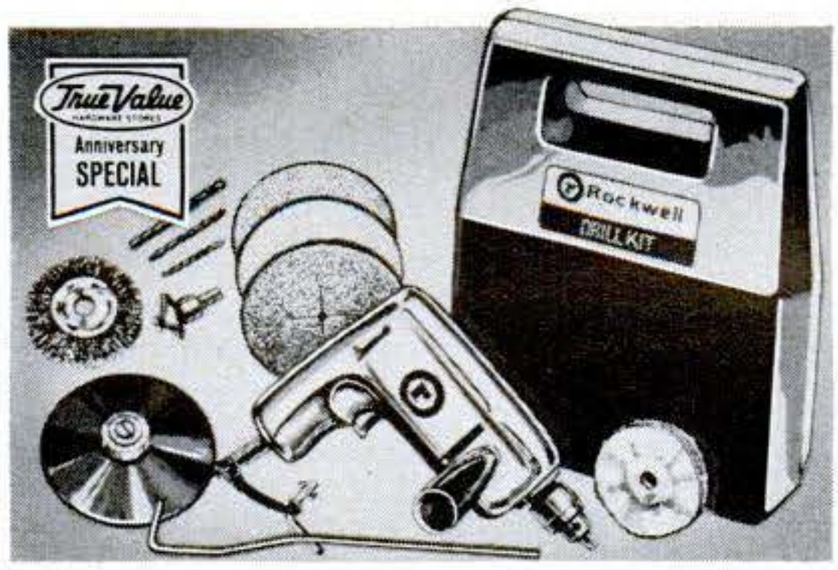

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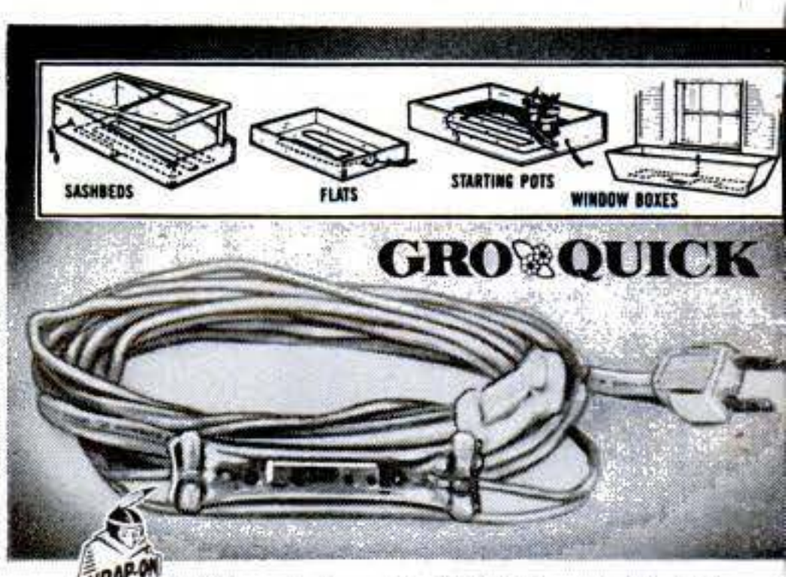

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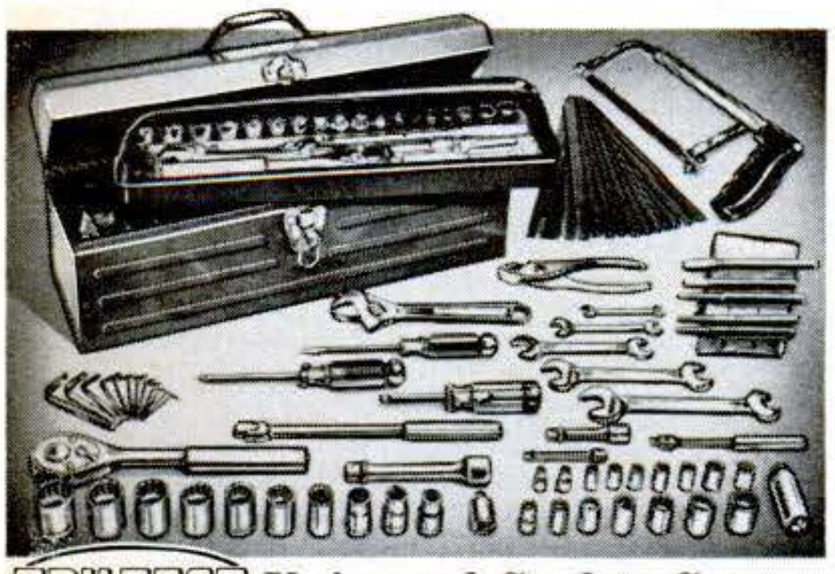

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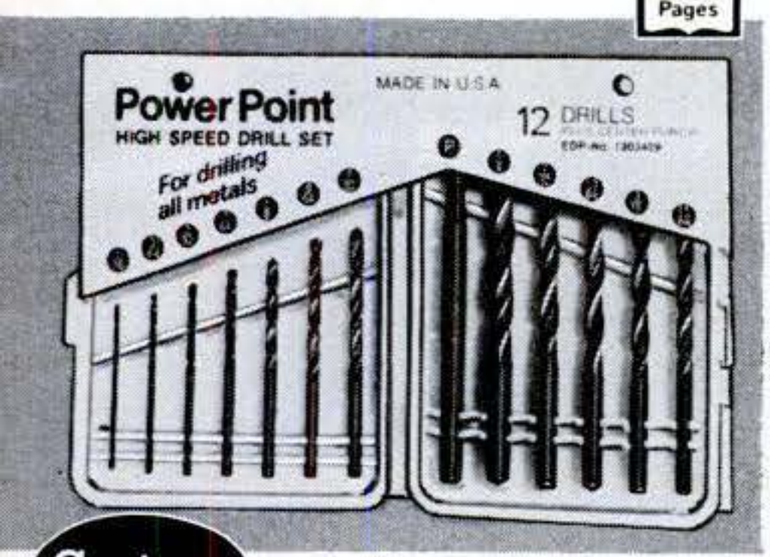

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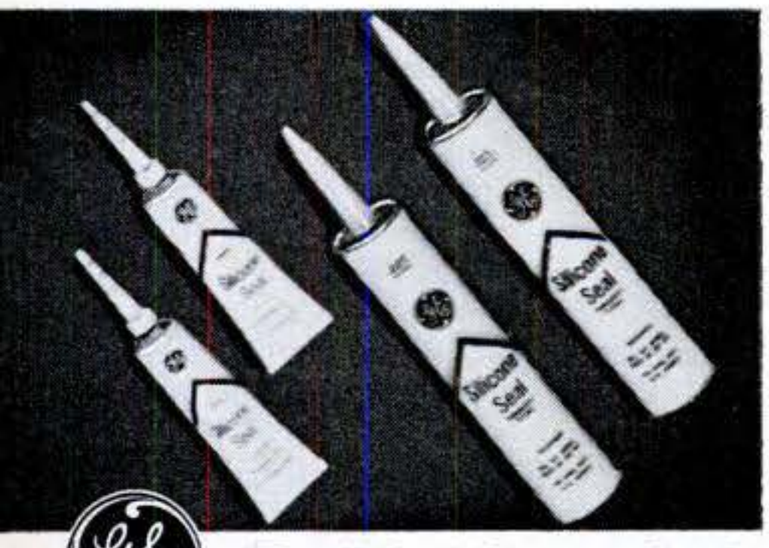

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PS Readers Talk Back

Where you voice your views . . . and the editors do the listening

Feds 'n' cars, cops 'n' robbers?

The new cars make me sick with all the imposed Federal regulations. They are going about automobile safety the wrong way. People cause car accidents, not cars. So they should push for better driver-education programs that teach drivers how to handle a car to avoid accidents.

We need cars that are quick and agile (without being overpowered), that respond to sudden steering without body roll or lean, and that have definite road-feel and holding characteristics. Don't be so gung-ho on a car that survives accidents; I'd rather have one that I can avoid one with.

RICHARD HAUSER, Honolulu, Hawaii

Back roar on ORVs

I was interested in your article, "The Uproar Over Off-Road Vehicles" [Dec.]. Actually, I don't believe that any organization, including the federal government, has made a thorough study of ORVs to judge whether or not these units are causing substantial damage to the terrain. We've seen areas where three or four Jeeps have practically ruined the vegetation. On the other hand, we have witnessed 20 or 30 vehicles properly handled that caused little or no damage. Our main problem appears to be with the individual.

In a discussion with the office of the Bureau of Land Management, we find they intend to do some studies on ORV-driver behavior in the future.

BERNARD C. HARTUNG, Staff Member, U.S. Senate Committee on Interior and Insular Affairs, Washington, D.C.

. . . ORVs? That's not the uproar. The uproar's over the drivers. The environ-

ment will survive the machines if we can survive the drivers.

BLAINE MCGIVERIN JR.
Howard City, Mich.

. . . The type of research being done in this area usually misses the point of the total damage caused. It is not a simple study of how much is done to plants run over by a vehicle or the fright of certain animals. There is simply no way to pour huge masses of people and machines into an area without its subsequent deterioration.

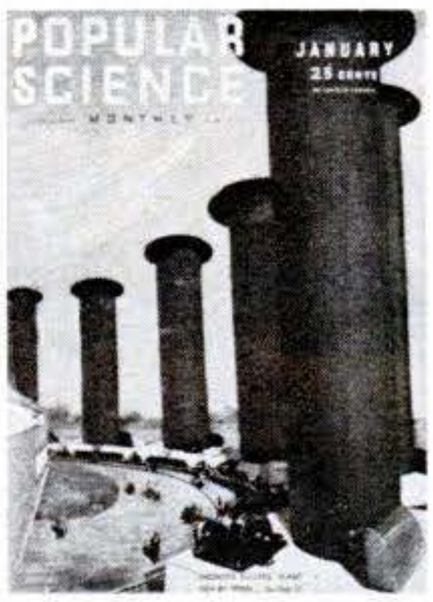
LEE DOUGHTY, Bellingham, Wash.

Postscripts on windmills

In "Can We Harness Pollution-Free Electric Power From Windmills?" [Nov.] you omitted mention of a project that caused some stir in the early 1930s. It was an adaptation of the rotor ship, in which a tall cylinder was mounted amidships and rotated slowly, causing it to act like a sail. The idea was to mount a number of such rotors on flat cars and sail them around on a circular track with generators geared to the axles.

There were some vibration problems, which the inventor, Julius D. Madaras, claimed to have solved. He blamed the Public Utility Holding Company Act of 1934 for breaking up a syndicate of power companies and thus shelving a Minnesota pilot project.

GEORGE TILLEY, Hickory, Pa.



PS ran a cover story on the project in the Jan. 1932 issue.

. . . The photos you published of the Vermont wind turbine brought back a lot of memories for me. I was the superintendent and field engineer on the project.

I am glad to see interest in wind power revived because I believe it does have a future. However, I'm sure if the promoters research the problem sufficiently, they will discover that the fixed costs per kw of installed capacity rule out the feasibility in any location other than one where no other source of power is available. And, in order to supply enough power for even a small town, the area would have to be ringed with windmills. True, there wouldn't be any air pollution, but people would complain about pollution of the scenery.

STANTON D. DORNBIRER, Inglis, Fla.

Insulation tip for winter

I read with interest your article "Is Your Insulation Up to Winter?" [Nov.]. One important item you didn't cover was the need for adequate air circulation and venting of the outside wall in addition to use of proper vapor-barrier material on the warm side of the insulation. I found this out the hard way after finishing my second house. The inside of the

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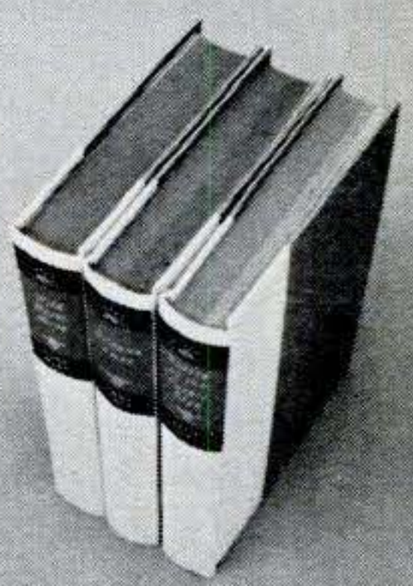

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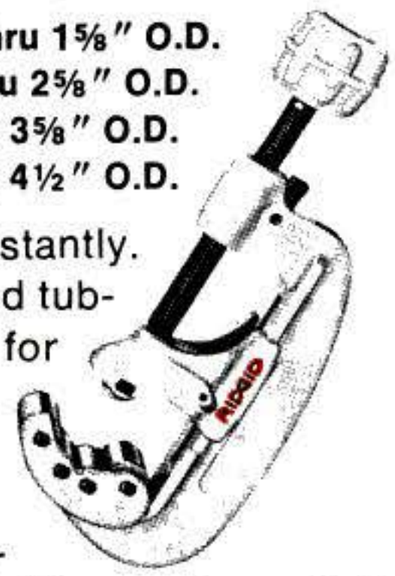

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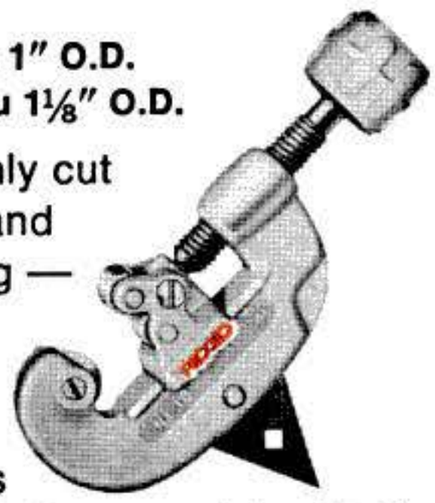

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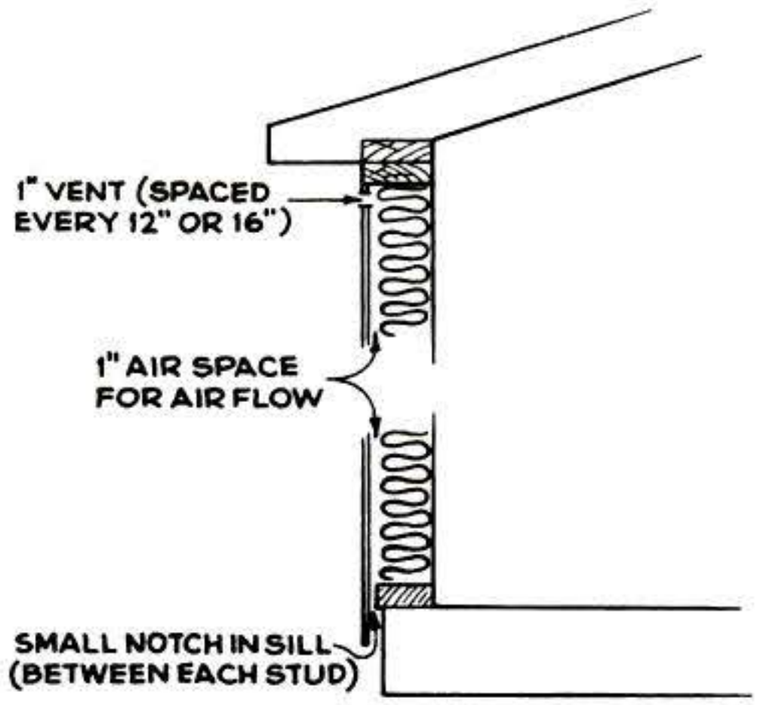
PS Readers Talk Back

[Continued]

exterior wall, which was plywood, was soaking wet with water running out on the floor in places. I had to drill one-inch-diameter holes between the studs



at the top of the wall and insert little screened-aluminum vents to cure this problem, as shown in the sketch.

WALT PEDERSEN, Sterling, Alaska

FTU is car-builder, not FIT

There is a correction we would like to point out in your article "The Race to Design the Ideal Urban Car" [Nov.]. Florida Institute of Technology had no entry. The vehicle described was from Florida Technological University in Orlando, part of Florida State University.

BRUCE NIMMO, Orlando, Fla.

Power steering for safety

I would like to take issue with W. H. Kirlin's letter [PS R.T.B., Dec.] questioning the value of power steering as a safety factor. Hitting an obstruction or having a blowout can jerk the wheel out of one's hands. Power steering permits the driver to maintain control.

BRYAN MICHAELIS, Fredericktown, Mo.

'73 bumpers: a continuing story

Bill Smith said in PS Readers Talk Back [Dec.] that the '73 bumpers are ugly and he wouldn't buy a new car until they take away the "fortress look." Don't worry: it's just going to take Detroit a little while to shrink them.

CLIFF PRYOR, Greenville, S.C.

. . . I would rather have the "ugliest thing I've ever seen" on my car than have someone cost me hundreds of dollars in the parking lot. Also, would you rather be dead or have a good set of bumpers on your car, regardless of what they look like?

BRAD CROWGEY, Roanoke, Va.

PS keeps ice maker cool

Without "How Ice Makers Work—What to Do When They Don't" [July '71] I wouldn't have had the courage to tackle my refrigerator ice maker.

As a tip to other readers, my problem was water dripping from the ice maker after refill and eventually forming a big glob of ice in the bottom of the bucket. I never had the icicles described in the article, but decided the water was creeping over the edge of the mold by capillary action as you described. Applying silicone grease along the edge and lowering the water level provided the fix. Many thanks for this story and your other appliance-troubleshooting articles.

EDWARD S. COLEMAN JR.
Mechanicsville, Va.

More on chain saws

We enjoyed "The Care and Proper Feeding of Chain Saws" [Oct.] but would like to clear up some inaccuracies that crept into the story:

Saw users should never use a screwdriver to pry the saw bar; saws are equipped with screws to allow for chain-tension adjustment.

There is no such thing as a self-sharpening saw, but there are built-in chain sharpeners on some models.

Finally, you say that the saw bar should be turned over each time you sharpen the chain so the groove will wear evenly. Actually, it should be turned over each day or two of use.

We'd be happy to forward our chain maintenance manual free to any PS reader who wants one.

G. E. HODSON, Oregon Saw Chain Div.
Omark Ind., Portland, Ore. 97222

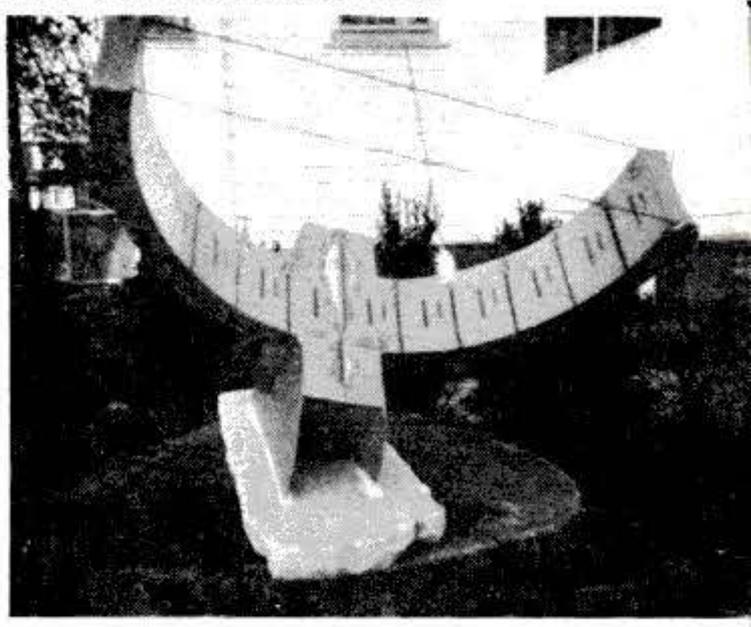
Oops on Temp Cube part

I've started to order the parts for your latest electronics project, "Temp Cube—a Digital Indoor/Outdoor Thermometer You Build" [Jan.] but found the parts list calls for R1 and R2 to be an E000 resistor. What's that?

SCOTT MELE, Hightstown, N.J.

It's a printing error. We did catch it early, but not before some copies were off the press. The correct value is a 1000-ohm, ¼-watt resistor.

Sun clock tells the time



Here is a photo of the sun clock we built from your plans ["Amazing Sun Clock Tells Time Right to the Minute," July '72]. We made changes in the plan for our latitude and also corrected the longitude so the clock showed Eastern Standard Time. The clock needed only a few minor accuracy corrections.

ROBERT ARTIS, Terre Haute, Ind.

Want to get something off your chest? Write "PS Readers Talk Back," Popular Science, 355 Lexington Ave., New York, N.Y. 10017.

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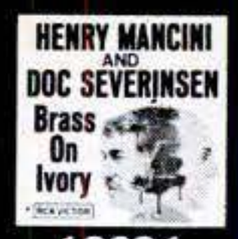

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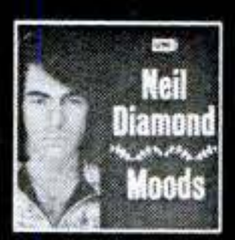

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TWIN SET
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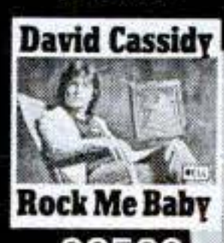

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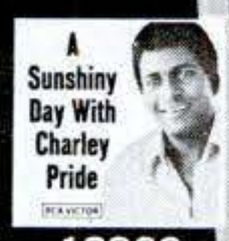

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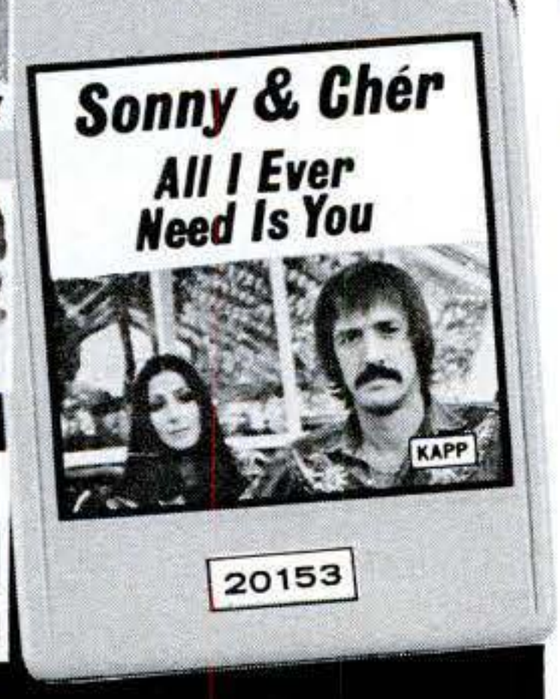

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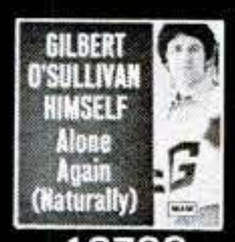

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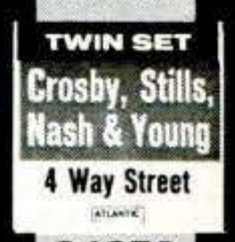

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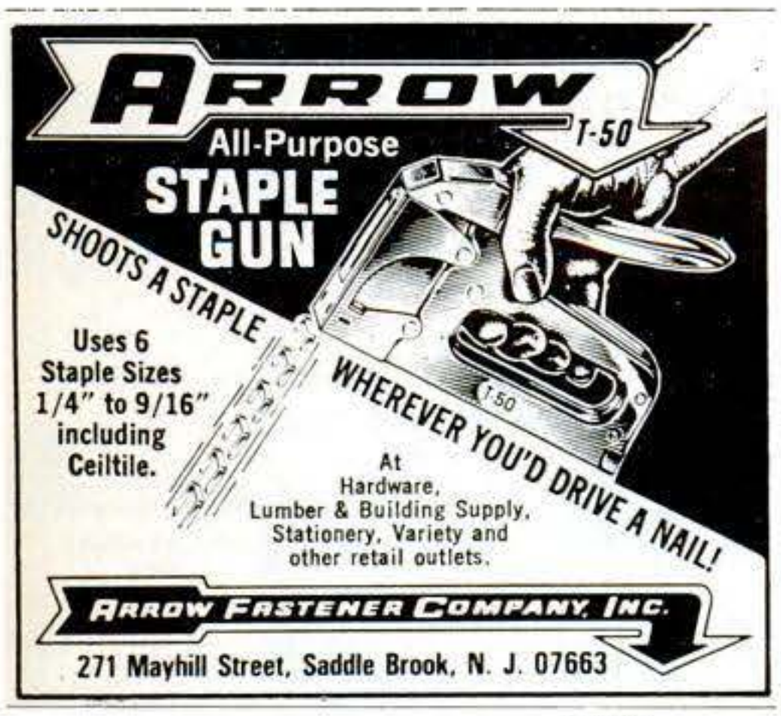

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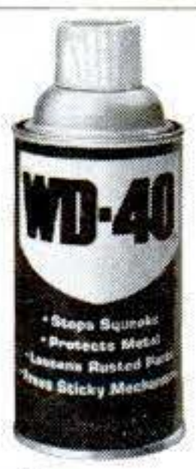

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Launching the Vinta (even with sail raised) is an easy job for two people, though it can also be done singlehanded. You use the outrigger braces as handles. Even if it's swamped during launching or beaching, it will still carry a full load.

Vinta is a very stable boat under sail, thanks to her outriggers. Author Jim Davis tried to overturn her during high winds but was unsuccessful. She comes about quicker than many multihull sailboats and maneuvers smoothly, according to the author.

VINTA: An Outrigger for Sail and Surf

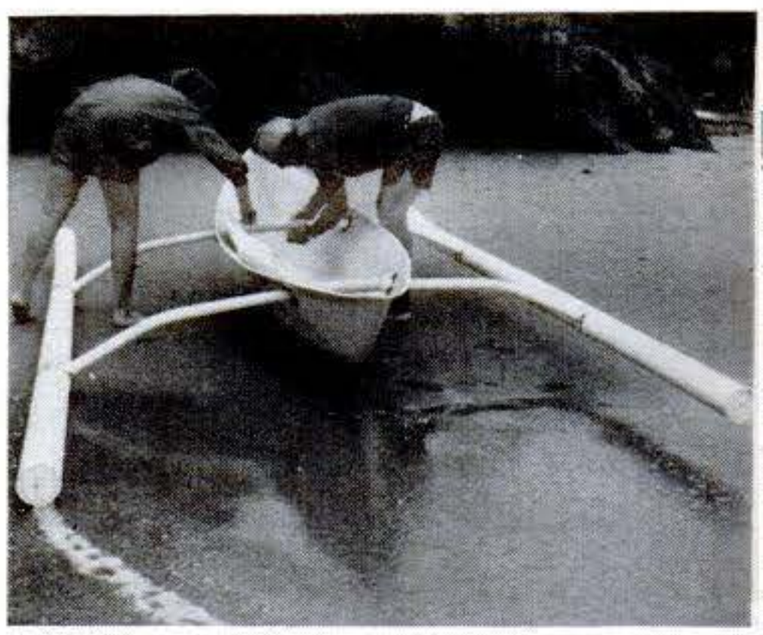
There's no doubt about it. More and more people are looking for multipurpose boats that can be knocked down and easily transported from one place to another.

Recently I took a ride on one such craft: the Vinta, a 12-foot cartoppable outrigger. You can sail her, or paddle her like a canoe. You can even mount a small outboard on her fiberglass hull.

Rudder control is just like that on the old Polynesian outriggers. There's a paddle that's placed in a mounting bracket near the stern. This gives the Vinta greater maneuverability than many multihulled craft, especially in tight quarters. The Vinta's rigging is lateen with 85 square feet of sail on its 12-foot mast. Sails are offered in a variety of colors. Two outriggers keep the Vinta stable and afloat under almost any conditions.

The Vinta can be ordered with or without the sail, but paddles and paddle/rudder mount are standard equipment. An engine mount and a conventional rudder are also available.

For more information, write to Vinta, 33856 Diana Dr., Dana Point, Calif. 92629.—*Jim Davis*



Lightweight frame consists of a one-piece fiberglass hull and two outriggers that separate for easy transporting. All you need now are mast, boom, and sail. No tools are required for assembly or dismantling; wingnuts are used throughout.

Shallow draft allows Vinta to navigate through waters that might inhibit larger craft. Even at her full 500-pound capacity, she'll draw almost the same as with two aboard. Two crewmen above paddle among the rocks with no problems.

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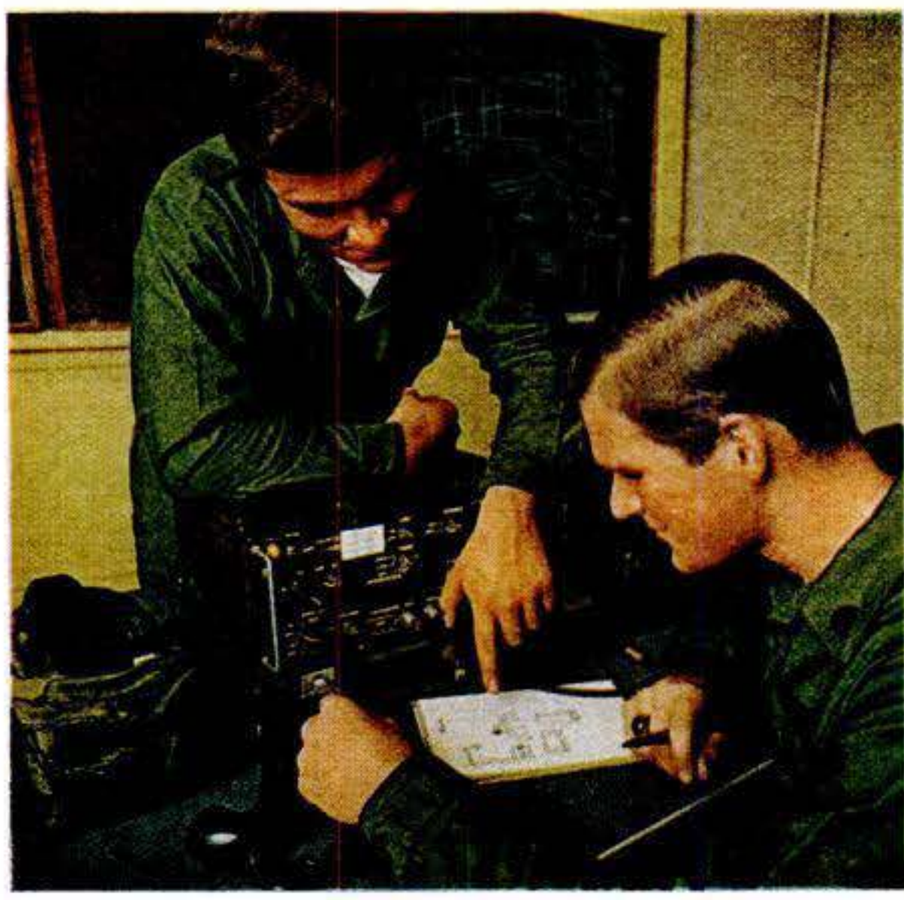

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Your Midas dealer will give you the facts you need. He's going to give you accurate tongue weights, heights, widths . . . facts about the new Midas electrical system . . . facts about roadability. He knows about towability and what mom needs in the kitchen. In fact, he's got more facts than you'll ever need.

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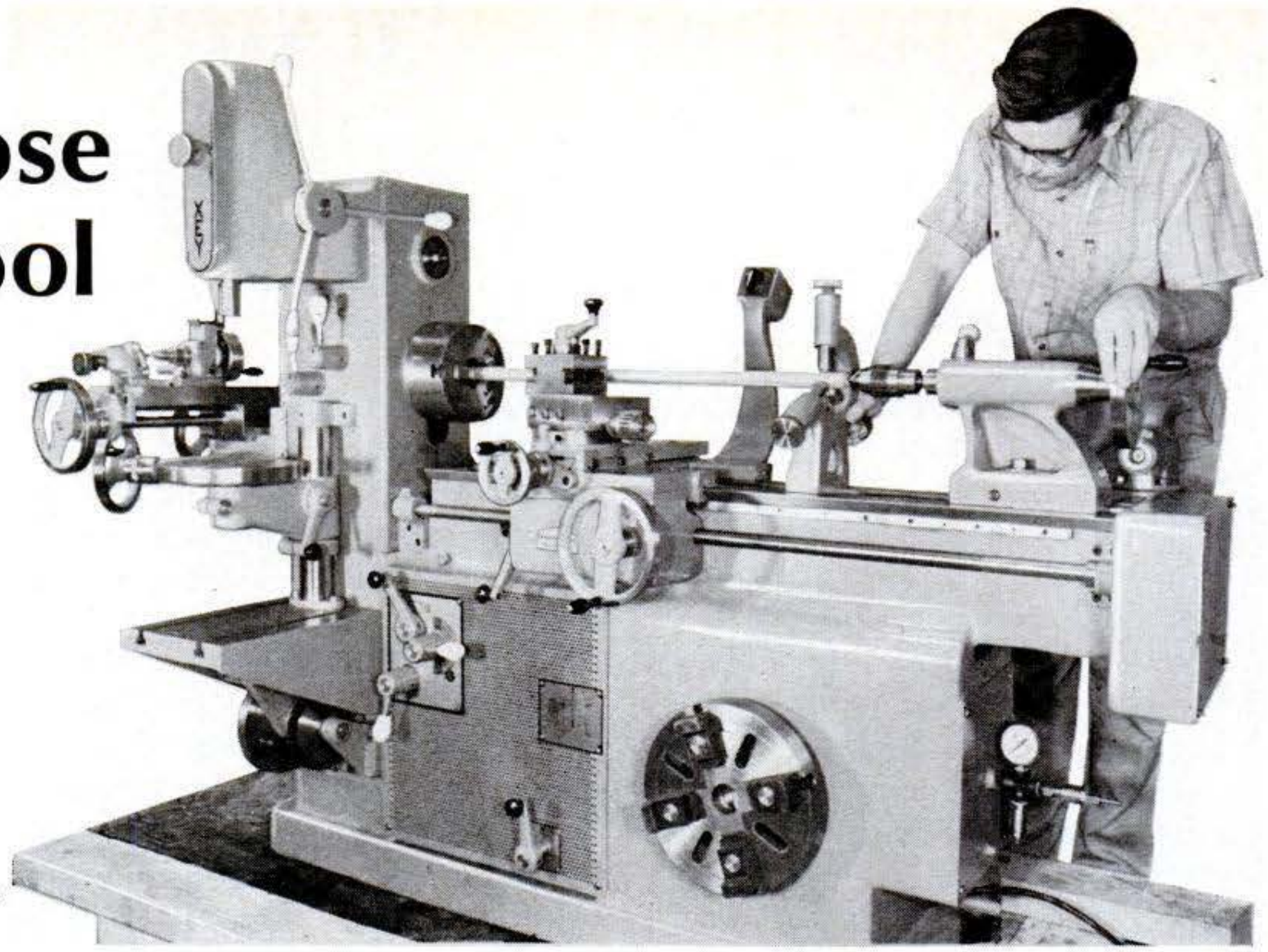
BIG SIX: Multi-Purpose Machine Tool from Spain

It weighs a ton and costs a bundle, but it can't be beat for versatility

By MACK PHILLIPS



Many roles of Big Six are reflected in a maze of cranks and levers.

Drill press has adjustable, swing-away round table and a T-slotted base table. Lathe-change gears store under the mill knee.

For the workshopper who has everything—or needs everything—here's a machine that is to metalworking what the Shopsmith is to woodworking. And then some.

In Spain, where it's made, it's known as the Maquina Multiple Xey (that's Basque for Multiple Six Machine). I call it the Big Six. In any language, it's six metalworking machines rolled into one: geared-head screw-cutting engine lathe, horizontal milling machine, power hacksaw, drill press, two-wheel grinder, air compressor with storage tank. Accessories further extend its versatility.

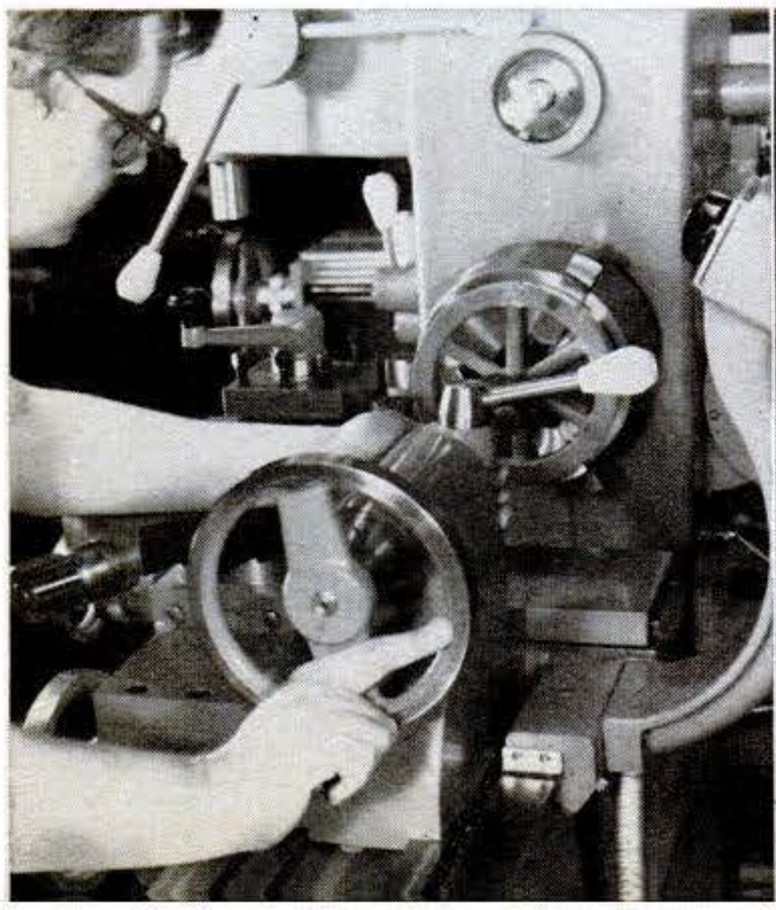
Unlike its well-known woodworking counterpart that requires some switching around to make it do different jobs, this dream machine is ready to go in any mode with the flip of a clutch lever that engages each function except one: lathe-spindle operation.

It is big and husky. If you're itching to get your hands on one of these utilitarians, it will just go through an average shop door—and you might have to take the jamb off to make it. And it's no toy, weighing a bit over a ton. Furthermore, it is not exactly cheap—although it may actually be a bargain if you tote up the separate prices of a 13½"-swing engine lathe with a 1-9/16" hole through the spindle, 20"-by-6" table mill with 11½" throat, and the other four basic machines it is. The two-horsepower motor requires 220-240-volt power.

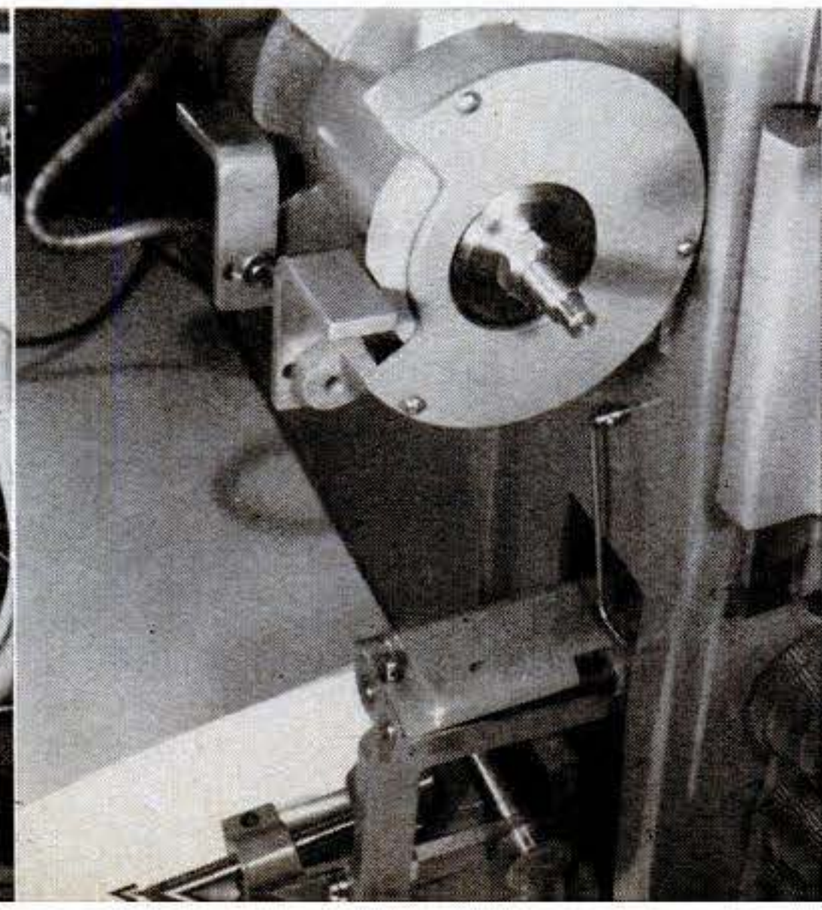
How it performs. As much as I wanted to take the machine home for a long, long trial, the proportions obliged me to settle for trying it out at the importer's place.

[Continued on page 162]

Husky size of machine components makes Big Six easy to operate. On-off-reverse switch is the dial on arm at upper right.



Tool-grinder and power hacksaw below it are located at back of machine. Accessory flex shaft fits to extended grinder spindle.



Accessory vertical mill head fits in place of horizontal mill arbor. Broad, husky ways make the miller a smooth performer.

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Recreation Roundup

. . . on the go with PS

By HERBERT SHULDINER

New rugged, go-anywhere motor home can take you into the boondocks

This no-nonsense rig has a steel chassis and frame that's designed to take everything that rough country can dish out. The Roxor 19 is built on a Dodge chassis with 360-cu.-in. engine and automatic transmission. Its four-wheel-drive power train is the same as used in Dodge trucks. On the inside it's rather Spartan, but packed with accessories for outdoorsmen. Price is $20,700 f.o.b. from Roxor, Inc., Rock Creek, Ohio.

Previewing the '73 RVs

I recently spent four days in Louisville walking around the cavernous halls of the Kentucky Exposition Center to get my first look at this season's new campers, trailers, and motor homes.

The place was bulging with over 1100 RVs—all sizes, shapes, and prices. A few hundred more overflowed into the parking lot outside.

PS will bring you a full report on many of these next month, with four pages of color photos. Meanwhile, here's a preview of what we saw:

Fifth-wheelers have really mushroomed. Last year only 29 were shown. The new ones are bigger and even more luxurious than before. And although most RV executives I spoke to felt that fifth-wheel sales hadn't achieved real significance yet, they all admitted they had to come up with them "in order to be competitive."

Motor homes grab the spotlight

Because they are the highest-priced item, motor homes command the most attention. Most manufacturers of consequence displayed at least one. Those who didn't are eager to break into the market. Top executives for Airstream and Avion told me they are planning to have motor homes in their dealer's showrooms in two years. Obviously they're aiming at producing spiffy top-of-the-line models.

Conspicuous by its absence was the GMC motor home, but it was widely discussed. Mainly RV companies felt that GMC was having problems getting it into production. But the new motor home was introduced to the press a month later in California. It will sell for between $12,000 and $16,000, GMC says, when it goes on sale shortly.

More motor homes from Detroit?

We learned that Chevrolet had 18 engineers at the Louisville show, going over motor homes with a fine-tooth comb. One informant told us the contingent included an engineer assigned the job of coming up with a design for a Chevrolet motor home to be sold through Chevy dealers. When I asked Chevy about this, a spokesman emphatically denied it, stating that the company is interested only in selling chassis to motor-home builders. The engineers were merely observing the state of the art, he said, with an eye on improving their current motor-home chassis.

Meanwhile, Chevrolet introduced a new 158½-in.-wheelbase motor-home chassis at the show, and a 178-in. chassis a month later. There are now four Chevy motor-home chassis. The big 178-in. chassis has better braking, and 14,000-pound GVW. The 158½-in. model will also be available with the same GVW.

Ford flexes its RV muscle

The Dearborn-based auto giant introduced a new 11,000-pound-GVW motor-home chassis, the M-450, in Louisville. It will be available in 125-, 137-, and 159-in. wheelbase, and will come with either a 360- or 390-cu.-in. engine. Radial tires will be offered as an option.

Pickup campers that Ford will start selling mounted on its trucks this year weren't ready for the show. But we've learned the camper will have a molded fiberglass body. It is now in final testing, will be in production shortly.

International rolls out a "pusher"

The big truck maker, trying to improve its foothold in the RV business, had a big surprise at the show—a rear-engine motor-home chassis. There's already at least one "pusher" on the market—the FMC 29-foot motor home, on FMC's own chassis. But this could start a whole new trend in motor-home design.

International has already supplied a prototype to Starcraft, whose engineers have been constructing a "box" to fit it. One big problem is getting enough air to the engine. The engineers are trying all kinds of intake systems to solve this. Another problem is finding a way to adequately insulate the rear of the motor home to keep out noise.

But the International "pusher" opens up possibilities. It will do away with the big hump that front engines make inside. Big rigs can be built lower to the ground, since there'll be no drive shaft running to the front axle.

Now the race is on to see who will be first on the market.

A new class of motor home

Dodge, which already has the major share of the motor-home chassis market, came up with another new wrinkle that will inaugurate a whole new category of motor homes. It previewed a new 145-in. chopped-van chassis at the show, which will establish a midi-motor home category.

Mini-motor homes built on a shorter van chassis really fueled the motor-home boom in '72. About 102,000 motor homes were built that year, and the RVI expects a 48 percent increase to 151,000 this year. Chances are the midi-motor home (which will be about 21½ feet long) will help to achieve this astonishing increase.

Bread-and-butter RVs

Travel trailers are still the main staple of the RV makers. Nearly 400 were spaced around the Louisville hall. Frankly, their relationship to camping grows more remote every year. The new ones are more luxurious than ever. Manufacturers tell me that's what you all want.

The new rigs look like efficiency apartments. Interiors are enormous. Many trailers now have big bathrooms, including tubs and separate mirrored vanity areas. Bigger appliances are going into the kitchens: four-burner ranges with big ovens, seven-cubic-foot refrigerators and double sinks.

Very little new engineering showed up. Exceptions: Holiday Rambler now incorporates the outrigger Mor/Ryde suspension in some models as an option. Airstream offers an optional Thermasan waste-destruction system. It is connected to the towing vehicle's exhaust manifold by a hose and the waste is pumped in to be burned up.

There's also a trend to better insulation, recognizing the all-year use many trailers get. PS

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This 50-mile-an-hour Evinrude 65, for example.

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It's tournament class all the way. As a fishing motor. A ski motor. And a world marathon record racing motor.

It does things better by doing them more efficiently.

Part of the secret is a loop-charged powerhead that eliminates the deflector hump on the piston and in the combustion chamber.

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Part is a new kind of piston ring that seals with combustion pressure instead of spring tension.

Part is super-sophisticated exhaust tuning that turns exhaust energy into usable power.

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Now you can be a hot dog on a hot dog budget.

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The View Down the Road

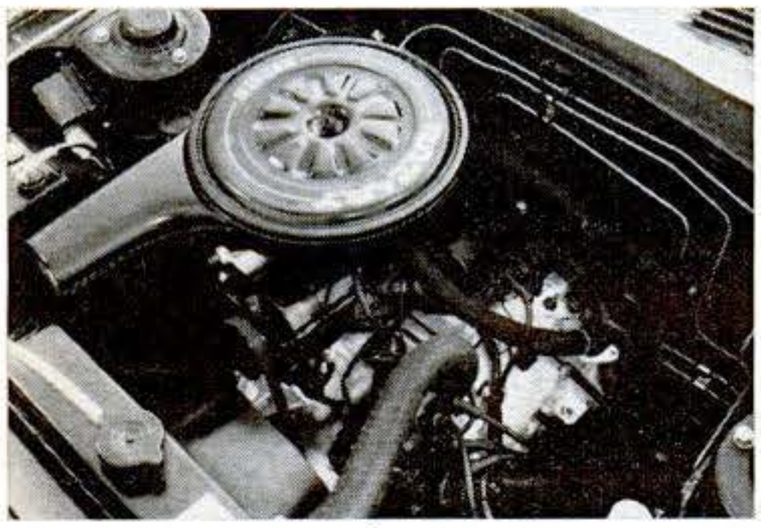
...news and comment on cars and driving

By **JAN P. NORBYE** / *PS Automotive Editor*

Datsun speeds up its Wankel work

Barely two years after signing a license agreement for the Wankel engine, Datsun has shown its first Wankel-powered car. The vehicle is basically the same as the 1200 series, and the power unit is a 120-cubic-inch twin-rotor. Datsun uses two plugs per rotor, like Mazda. Unlike Mazda, Datsun has chosen peripheral ports. Initial performance targets have been met, endurance tests of the engine have been successful, and Datsun is now in the "in-car" test stage. Production of a new and sporty model with the fully developed rotary engine will start during this calendar year.

The original agreement limited Datsun to an 80-120 hp range, but this has now been extended both ways—down to 30 hp and up to 230! The first license also specified that rotary-



powered Datsuns could be sold only in Japan. Now Datsun has acquired worldwide marketing rights. Datsun has suddenly got the jump on Toyota in the Wankel race. Toyota signed up at the same time, but has announced its intent to use Mazda engines (at least on a temporary basis). The conclusion to draw from developments in Japan is obvious. Mazda started two years ago on a course of total conversion to Wankel engines. Now, the rest of the Japanese auto industry is following in Mazda's footsteps.

Radial tires—the march is on

I bought my first set of Michelin X steel-belted radial tires in 1957 and have been sold on radials ever since. That doesn't make me a pioneer—Michelin started producing them in 1948. But when you realize that radials were fitted on only about two percent of new U.S. cars made in 1972, you start wondering about the rate of progress.

Yet there are encouraging signs. Now, as the radial tire celebrates its 25th anniversary, Gordon C. Applequist of Firestone says he expects an installation rate of at least 10 percent on the '73 cars. "And we see their use increasing dramatically by 1974 on new-car production in the United States," he added. Ford Motor Co. will install steel-belted radials on almost one-third of all its '73-model cars. Other auto makers will have to follow. Firestone has tripled its capacity for weaving steelcord into belt material.

And Firestone is not alone. Kelly-Springfield is adding over 25,000 square feet of floor space in a multi-million-dollar expansion of its Fayetteville, N.C., plant in an effort to radically increase production of steel-belted radials (and steel-belted bias-belted tires).

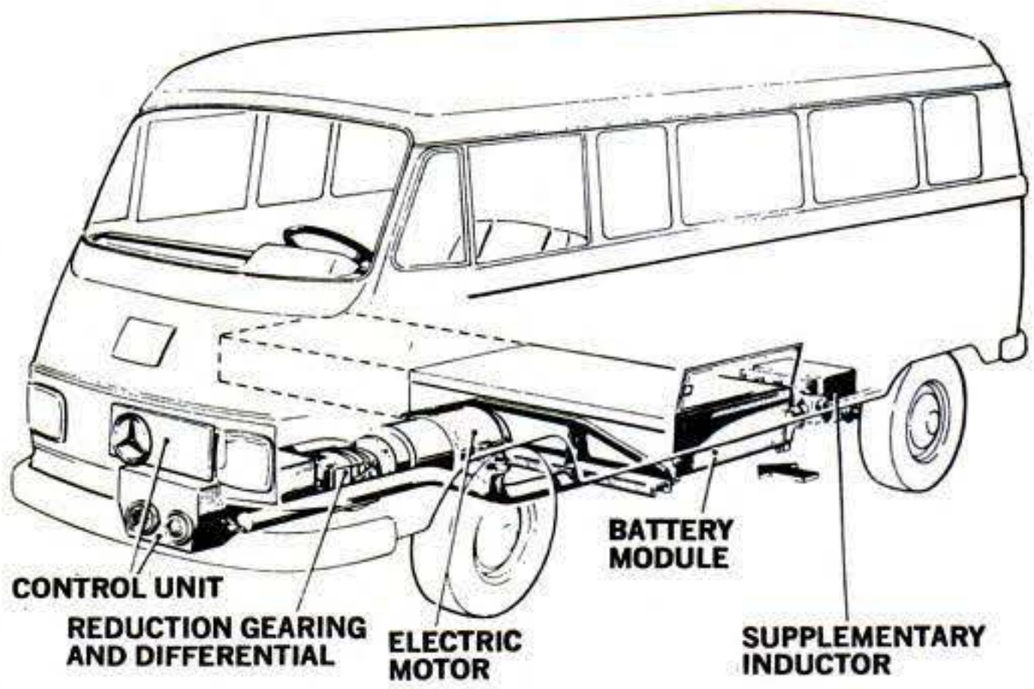
Looking further down the road, what will happen in the tire world? Don't miss this from Ford's O.D. Dillman: He predicts a supertire for the '80s with one-piece sidewall construction, all-weather tread, and run-flat capability, with a reinforced synthetic-resin wheel, 50,000-mile guarantee, and recyclability.

More hope for the Saturday mechanic

A year ago I started talking about the U-Tune centers in Michigan. Now, the do-it-yourself concept has gone far beyond the hobby stage, and Auto-Fix International of New York is establishing a nationwide network of auto-repair centers where you can do your own repairs and maintenance. A projected 75 to 100 locations will be opened this year. The rental charge will include the use of all tools and equipment, charts and manuals, and, if needed, professional guidance.

Electric utility-vehicle progress?

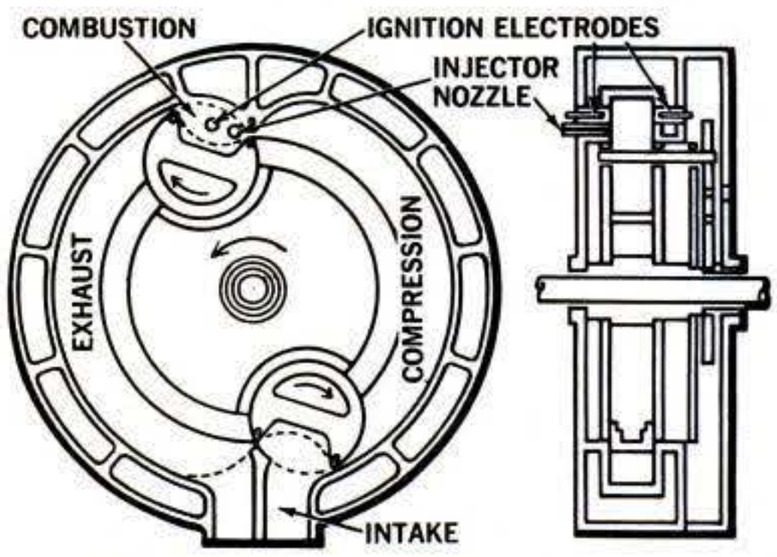
Things are happening all over. Last fall the Electric Vehicle Council ordered a fleet of over 100 vans for testing as multistop urban vehicles. A passenger version has also been designed. Built by the Battronic Truck Corp. in Boyertown, Pa., the van represents the state of the art, without any breakthrough in electric vehicle technology. Mercedes-Benz has built an electric conversion of its L-306 minibus. It uses a bank of 144v



batteries that can be quickly exchanged as a module (in line with VW's plans). Top speed is 50 mph, and acceleration from 0 to 30 only 12 seconds. The range is 40 to 60 miles. Again, just a restatement of the same problem: We don't know how to store enough electric energy in a small enough package to transport a normal-size automobile. Perhaps continued experiments with and demonstrations of existing technology will eventually show us where to direct our efforts in intensified battery research. In the meantime, electric vehicles are strictly for local use.

Oh no, not another rotary engine!

Development work on the radically different Tridyne [PS, July '69] seems to have been suspended. Last month we reported on the Anidyne. Your guess is as good as mine as to its chances. Now Rotor Power Ltd. in England proposes yet another type, looking very much like a simplified



compromise between Tridyne and Anidyne. It has two rotary valves, but no eccentricity and no reciprocating motion. It promises extremely high power density and simple manufacturing and assembly processes. Very few projects actually deliver what they promise, so we'll just defer judgment on this one. PS

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Presenting Datsun 610.

Considering the luxury, its economy is all the more remarkable.

The new Datsun 610 is something altogether new... a luxury economy car. A Datsun original.

Whether you choose the new 2-Door Hardtop, the new 4-Door Sedan or the new 5-Door Wagon, you get more power, more room, more quiet, just plain more car than any economy car has a right to be. But it comes with a Datsun price tag. And the kind of design sophistication you've come to expect from Datsun.

There's a new 1800 overhead cam engine and new power-assist front disc brakes for the perfect performance combination. The 4-Door Sedan and 2-Door Hardtop have a new independent rear suspension, too.

As for the luxury, well, you've really got to drive it to believe it. The luxury touches—whitewalls, fully reclining bucket seats, tinted glass, full carpeting and custom vinyl interior—are just a beginning.

It's the new Datsun 610 series. Sporting performance, luxury accommodations and an economy car price. You've got to drive one to believe it. Drive a Datsun... then decide.

Own a Datsun Original.

From Nissan with Pride

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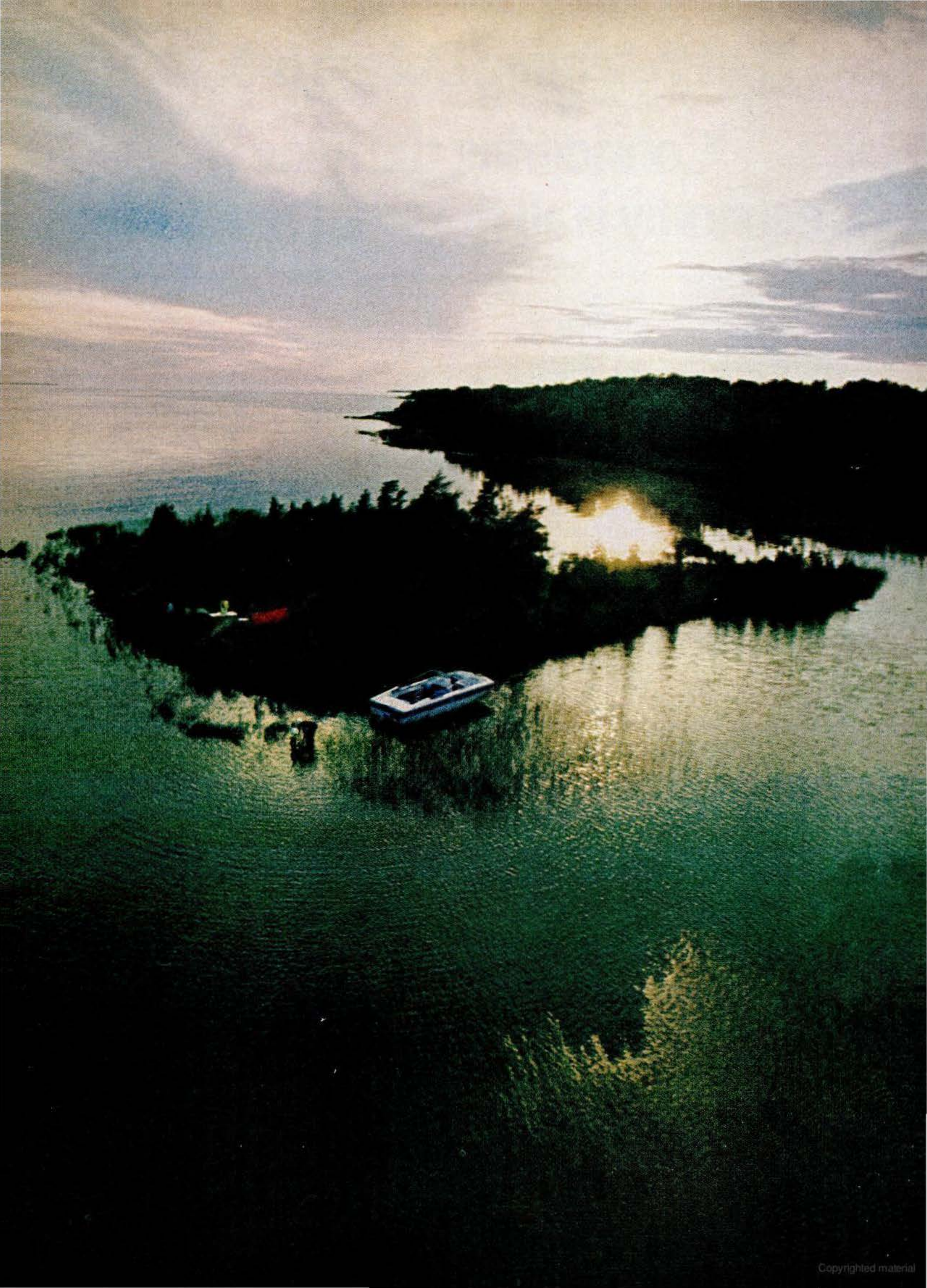

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If you took your family to the island for the weekend and this is what they remember, your boat was probably built with Starcraftsmanship.

Living on an island for a weekend is more than an experience. It's an education.

It's so quiet your kids can hear the water lapping their toes.

They can learn to water ski.

They can learn to go to sleep without a street lamp staring in their window.

And you can learn to wake up with the sun. Unalarmed.

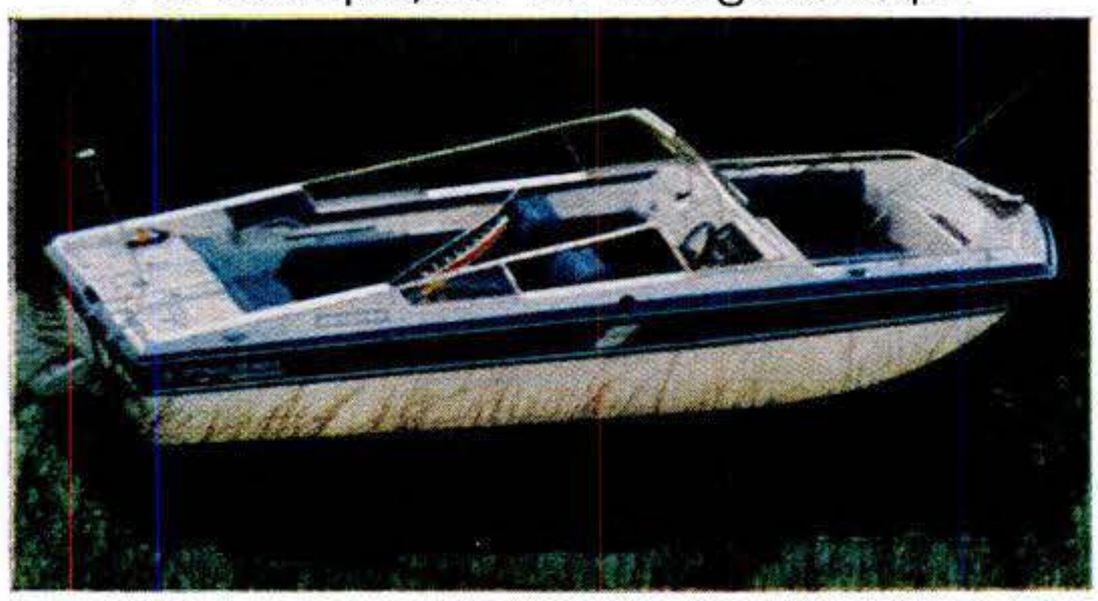
Those are the reasons people buy Capris and Americans. Not because you want a snappy bowrider or runabout. But because you want what they can give you.

At Starcraft we never forget that fact. That's why we build our boats so they make sure you will enjoy the experiences you get. It takes Starcraftsmanship.

Basically, Starcraftsmanship is a standard of excellence.

Coming up to that standard meant developing the leading research and design center in the industry. A center that recognizes different people want different things in a boat.

For example, our 20′ fiberglass Capri



is a big, family-style, roomy open-bow run-about. It performs beautifully, but because it's made with a wide modified tri-hull it rides smoother and safer.

Everytime a little wave rolls by it doesn't roll the Capri. When you corner it, you can enjoy looking into the water, because you're not afraid you're going to fall into it.

The 20′ fiberglass American is a sporty looking performance boat. The American performs so beautifully on the water you may not care if you ever get to your island. But you'll get there fast. Because its wide angle V hull cuts through the water sharply.

The American is also built for comfort. For example, you can have dinner cruising around your island. There's an ice locker

to keep your dinner in and fold-out tables to serve it on.

But more than features and the quality materials we build them out of, Starcraft puts value in craftsmanship. It's the reason our standard is Starcraftsmanship, and you get more value out of your boat.

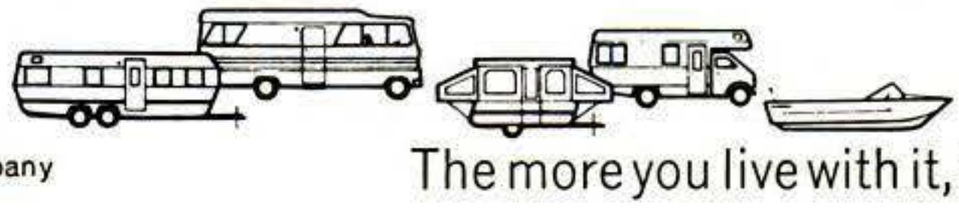
Starcraft is one of the few companies who test boat molds with refracted light to find possible flaws.

Every prototype boat is inspected by the Boating Industry Association.

And then they're tested on the water. They're driven. Raced. Capsized. Swamped. Everything we can think of to prove their perfection to us and to you.

After all, we want one of our boats to take your family to your island. And when it brings you back we want you to remember it as beautifully as you're picturing it now.

Write to us for more information about the Capris and Americans, and the name of your nearest dealer. Dept. F7-2 Starcraft Company, Goshen, Indiana 46526.



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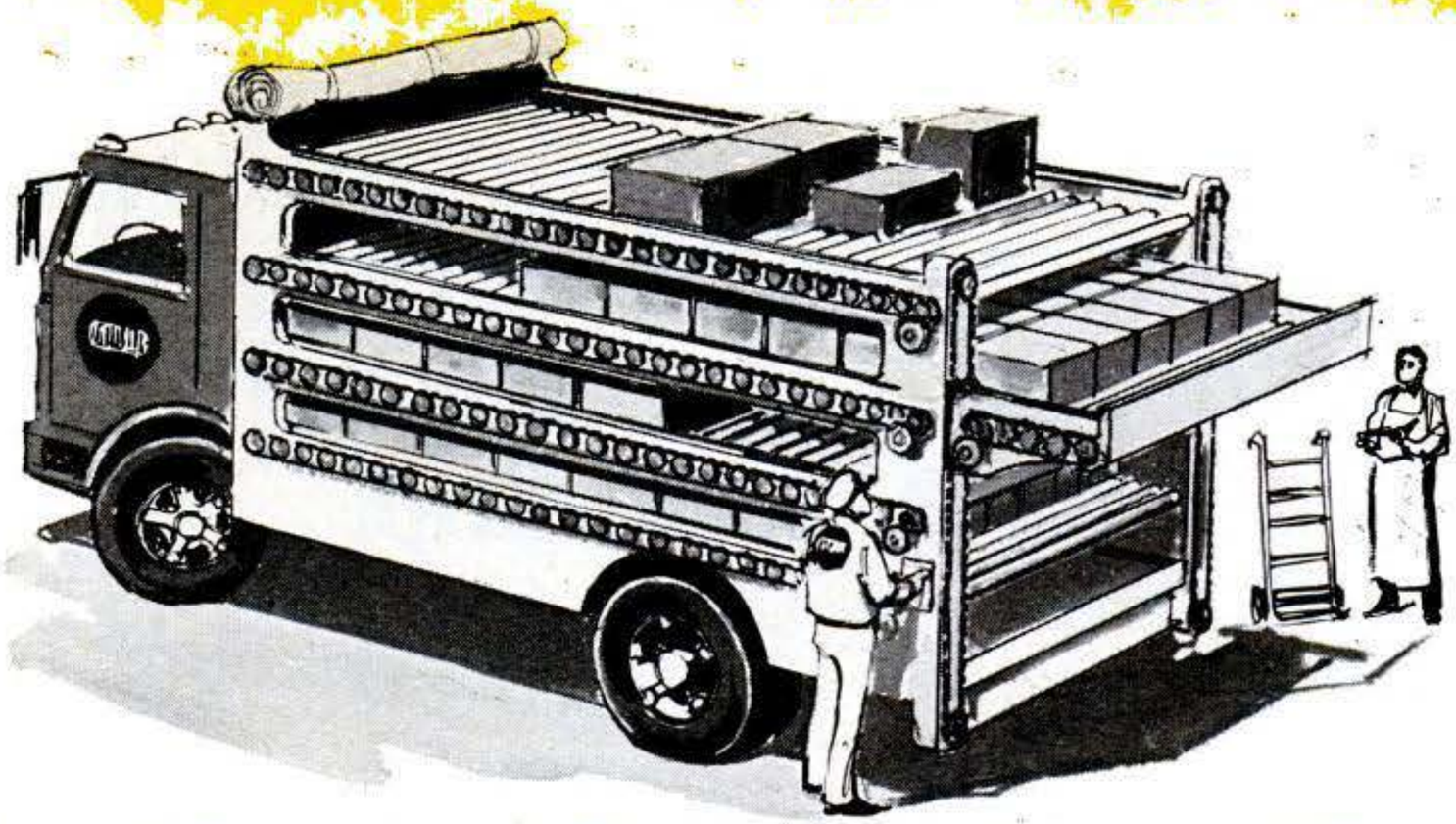
New Ideas from the Inventors

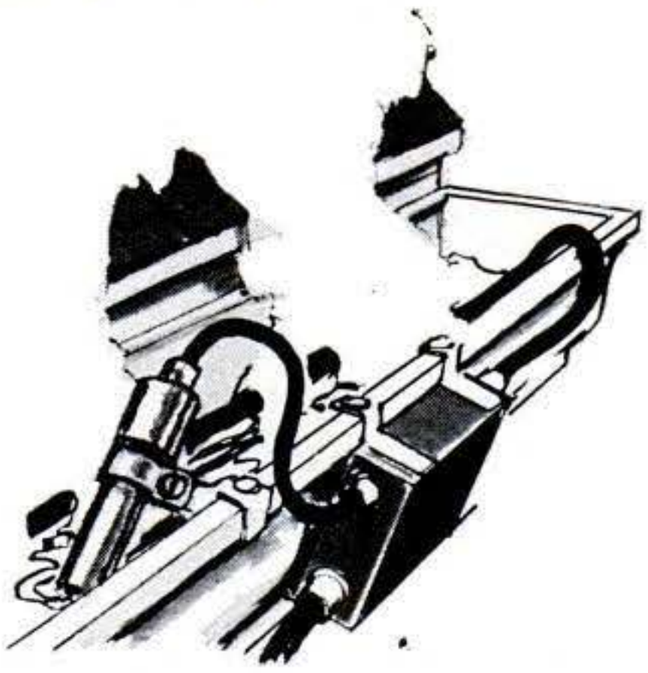
ILLUSTRATIONS BY DANA RASMUSSEN



Tiered rollers speed cargo handling. Vertically spaced for cargo units of different heights, the powered roller platforms of this recently patented delivery truck could be driven one way to load cargo from a tailgate elevator, switched the other way to offload a particular item. The system could shift cases from one level to another for quick, easy access to any package.

Trunk lid raises signal light. Hinged inside the edge of a trunk lid, this light could be swung down when needed so that its steady—or flashing—beam could be easily seen at a distance. When it wasn't needed as an emergency road signal, the light would fold flat inside the trunk lid, where it would be protected.

Packed crystals warm shoes. Piezoelectric crystals and some other particles generate energy when subjected to pressure. If such particles were packed into narrow cavities in a shoe sole, according to this inventor, useful amounts of heat would be produced when a wearer stamped or ground his feet.



Switch de-ices gutter. A thermostatic switch in this de-icing system would close a power circuit at freezing temperatures. Then the moisture-sensitive electrolytic switch shown would energize conventional heating tapes as needed to prevent ice and icicle formation in gutters and downspouts.

Hassock stores vacuum. A shelf and partition in this upholstered box would hold a tank-type vacuum cleaner and its hose and attachments. The useful piece of living-room furniture would eliminate the necessity of fetching a cleaner from a distant closet or storage room. The let-down door of the hassock would form a ramp for loading the always handy cleaner.

Probe bends flash beam. A flexible fiber-optic bundle with glass or plastic elements could multiply the usefulness of a light source manyfold. This inventor would use a special adapter to attach such a flexible probe simply and reliably to the end of a flashlight or penlight. You could then aim its spot of light at an otherwise hard-to-illuminate target.

The following patents have been issued on these inventions: **Load conveyor**—*No. 3,575,309 to W. B. Peterson, Clinton, Miss.;* **Trunk signal**—*No. 3,582,639 to J. R. Chamberlain, Gulf Breeze, Fla.;* **Shoe warmer**—*No. 3,493,986 to C. W. Erwin, Bal Harbour, Fla.;* **De-icing switch**—*No. 3,582,612 to R. Siemianowski, Chicago;* **Vacuum-cleaner hassock**—*No. 3,582,172 to D. H. Clark, Miami, Fla.;* **Flashlight probe**—*No. 3,582,638 to M. E. Peters, Xenia, Ohio.*

Copies of patents may be ordered, by number, from the Commissioner of Patents, Washington, D.C. 20231, at 50 cents each. To write to an inventor, if the address given is insufficient, address him (by name and patent number) in care of the Commissioner of Patents.

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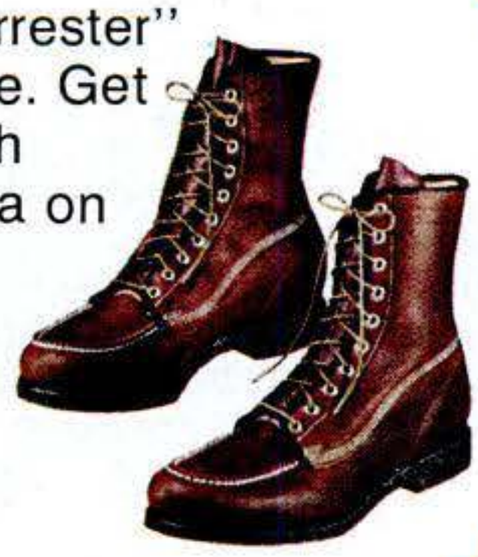

Smart new packs—same great taste.

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Filter Kings, 17 mg. "tar," 1.3 mg. nicotine; Longs, 19 mg. "tar," 1.5 mg. nicotine, av. per cigarette, FTC Report August '72

Warning: The Surgeon General Has Determined That Cigarette Smoking Is Dangerous to Your Health.

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Tough Little Chain Saw for the Home

Offer an 8¼-pound chain saw for $100, and the customer wonders: Can it do the job? Will it handle the trimming, small felling, and fire-log cutting he wants to do?

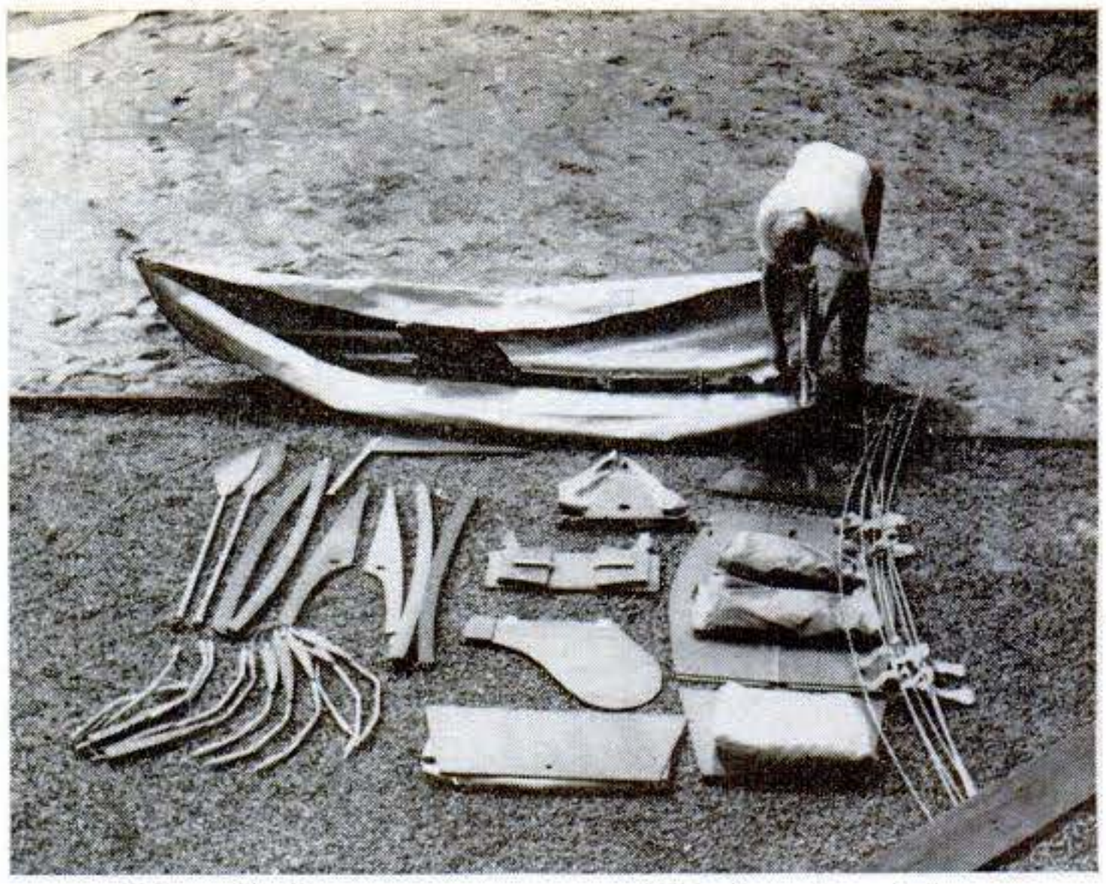
My answer, after trying McCulloch's latest lightweight, the Mini-Mac 1, is a definite yes. It starts readily, putts nicely at idle, and screams into action in all positions. That's important; with a saw of this kind you find yourself angling to trim unhandily placed limbs.

Starting is easy, but for safety I prefer a stirrup-type handle you can hold down with your foot. For fire considerations, I'd recommend buying the optional spark-arresting exhaust screen.

At $99.95, I found the Mini-Mac 1 a good buy for use around the home, trimming and firewood cutting, and light camp chores.—*E. F. Lindsley*

All-angle performance, manageable weight makes the Mini-Mac 1 a cinch for trimming.

Let saw set its own speed, to prevent blade-vibration marks as on cut section.



Assembling all those parts isn't as difficult as it might appear. An easy-to-follow instruction book is included.

Boat's mast fully extended for sailing is 17 ft. Telescoped for storage, it's 6 ft. 6 in.

Disassembled and packed, sailboat is carried here by its inventor. He spent two years developing it and making it seaworthy.

A Sailboat for Your Closet

Next time you go on vacation you can carry your sailboat along with your luggage—if you own a Stowaway.

What's a Stowaway? A nonsinkable 95-pound sailboat that stores neatly in two duffel bags. Packed, the bags tip the scales at 55 and 40 pounds. Inside the heavier bag are Dacron sails, floorboards, seats, centerboard, deck, bow, rudder, and hull. Highly resistant to tearing and deterioration, the hull's made of tough nylon canvas coated on both sides with sun-resistant Hypalon.

Opening the lighter bag, you'll find gunwales, ribs, girders, oars, boom, and keel parts. The girders and ribs form the hull's frame and are made of telescoping aluminum tubes. The mast is a telescoping aluminum tube, too, and it straps on the outside of the bag. Polystyrene foam stuffed inside the aluminum tubing, plus two vinyl air bags, provide extra flotation when the boat's under sail. If a sudden puff of wind capsizes the boat, they prevent it from sinking.

How does the Stowaway handle? I haven't taken it out, but the boat's inventor, Hugo Van der Heide of Nyack, N.Y., says handling the 10-foot craft is comparable to that of a rigid-hull boat of the same size.

Assembly requires no tools. I watched Van der Heide put it together in 14 minutes. But he's done it so many times it's second nature to him. He says a man assembling it for the first time takes about an hour. After that, assembly time decreases as you become familiar with it.

The Stowaway costs $795 and has a maximum carrying capacity of 500 pounds. An eight-foot model, 25 pounds lighter and $200 cheaper, is also available. Its maximum capacity is 350 pounds. Both models are made by Sport Skiff, Inc., Cedar Hill Ave., Nyack, N.Y. 10960.—*Ray Hill*

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Meet the new Omega. If you think you can't afford an Olds, think again.

A smaller Olds at a lower price. Omega is a whole new kind of Olds—a compact. But one with Olds big-car thinking built into three interesting variations: 2-door coupe, 3-door hatchback and 4-door sedan. All of them a lot of Olds for the money.

Omega is not your basic little car. It's nearly 500 pounds more car than some smaller compacts. The wheelbase is longer—111 inches. And you can feel this extra size and heft working for you on the road. It's solid and steady. Roomy. Comfortable. Agile and maneuverable.

You get what you bargained for. Omega gives you nice things you may have to pay extra for in other compacts. A deluxe interior with new "wet-look" vinyl trim. Full carpeting. Chrome trim around the windows and wheel openings. And 250 cubic inches of engine. There are also things some compacts don't offer at any price! A glove compartment with a door and a lock. Rear windows that roll down. And generous trunk space.

Add some neat ideas of your own. You can order a vinyl roof for looks. Our famous Rocket 350 V8 for go. Sporty high-back bucket seats and a console for the coupe and hatchback. Even a special tent that converts the hatchback into a camper.

It feels like a bigger car. Get into an Omega and notice the comfort. The way you sit up, how right the steering wheel position seems, how easily the car responds. Sure, you can get a lesser compact for less money—but then, it wouldn't be an Olds Omega. Oldsmobile. Always a step ahead.

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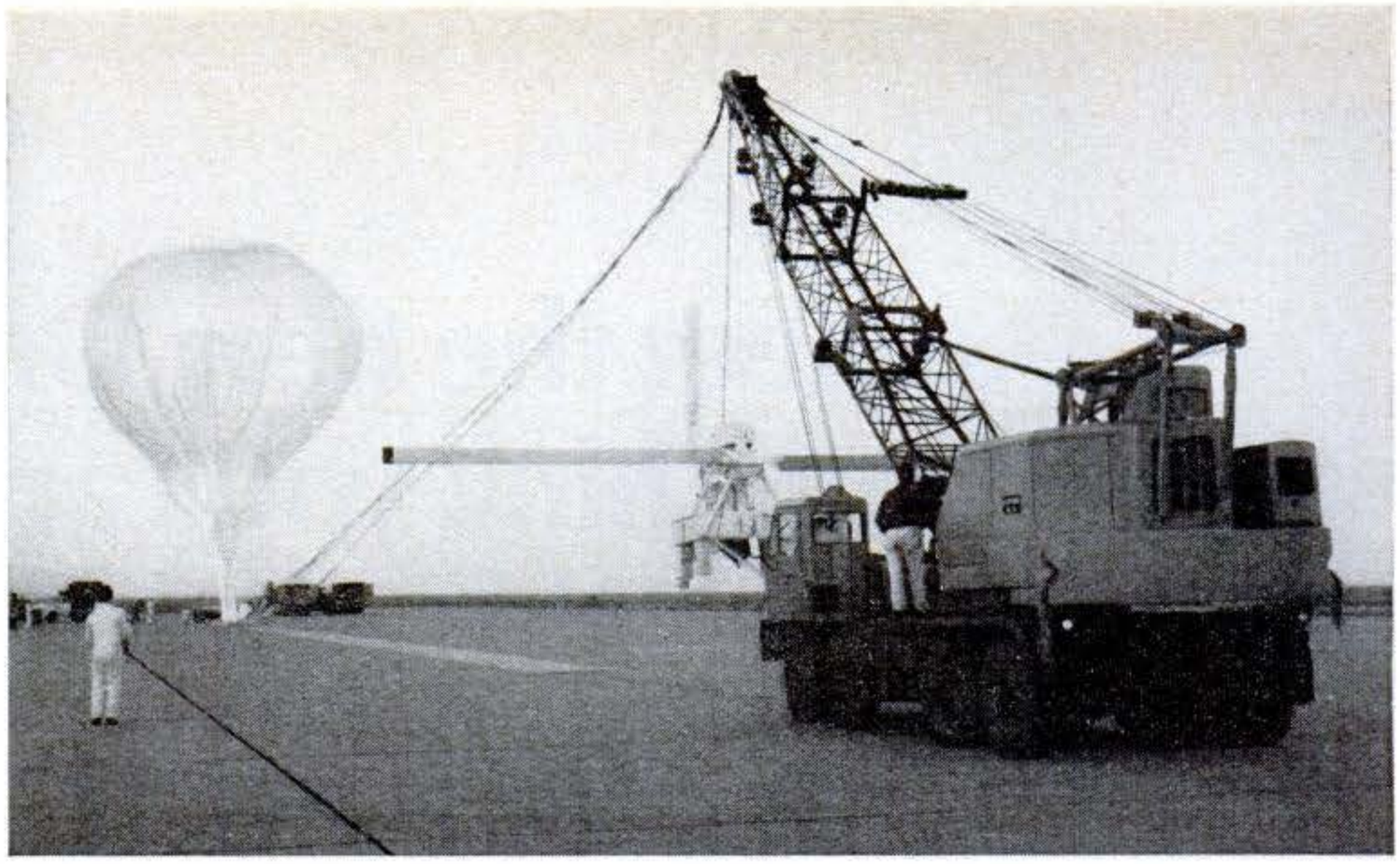
Science Newsfront

Last-minute news and notes to keep you up-to-date

By ARTHUR FISHER



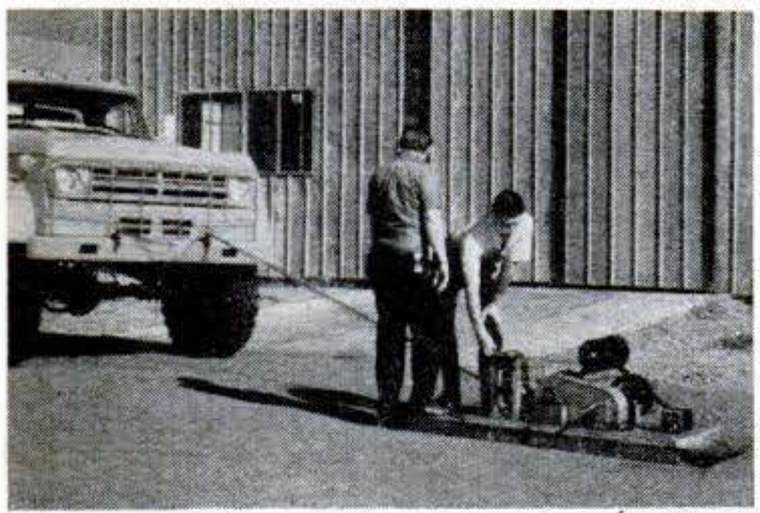
It's a bird . . . it's a plane . . . it's a powered balloon?

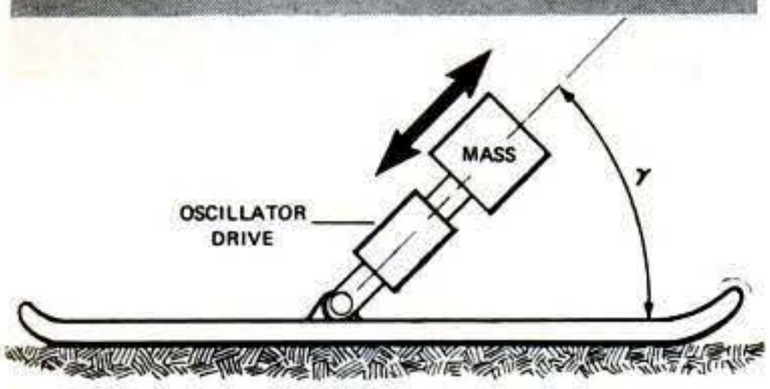
Yes, POBAL for short. Its proud masters at the Air Force Cambridge Research Laboratories recently flew the beast by remote control in a three-hour test flight. The hybrid system combines a free-floating gas-filled balloon and a dangling payload that looks like a wingless plane and has a 39-foot propeller driven by a 12-hp electric motor. Idea: to keep balloons carrying electronic equipment precisely on station even in strong winds.

Vibratory locomotion

You would think that with the wheel, air cushions, magnetic levitation, and some other recent refinements, man's ingenuity in the field of over-the-ground transportation had been just about exhausted. Not so. Now there's a new wrinkle on a technique that engineers have been tinkering with for years—you've probably seen it in toys. It uses an oscillating weight to make a skid or sled literally shuffle along the ground. And its advantages may result in its replacing the bulldozer in many applications.

The new system is called VIBRA-LO, for vibratory locomotion, and it was developed by Dr. Howard A. Gaberson, a mechanical engineer at the Naval Civil Engineering Laboratory, Port Hueneme,





Calif. Its basic principle appears in the drawing shown here. A mass moves up and down along a shaft diagonal to a skid, or sled, on the ground. Both up and down strokes have a force component that is parallel to the ground, and at first it would seem that every inch of progress forward would be canceled by an equal travel backwards. What makes the ingenious scheme work is friction. On every up stroke the skid is lifted partly off the ground, friction is reduced, and forward travel is eased. But on the down stroke, the sled is being pressed into the ground, friction is increased, and backward motion is braked. The net result of each complete vibration is a kind of shuffle forward. To change directions, all you do is rotate the angled drive shaft.

The experimental model you see here has a 100-pound oscillating weight, and it's pulling a two-ton truck. A newer model now under test uses a more sophisticated oscillating drive—a counter-rotating eccentric weight system with concentric shafts—which has "no limit in terms of weight, size, and power." Vehicles equipped with the system could outpull—slowly—bulldozers with three times the horsepower and twice the weight.

New value for speed of light

One of the most important of all constants in nature—*c*, the speed of light in a vacuum—has been determined with an accuracy 100 times greater than ever before. The triumph, achieved by scientists at the National Bureau of Standards Laboratories in Boulder, Colo., could have incalculable consequences in fields ranging from communications to spaceflight. It could, for example, permit an increase of 1000 times in the number of frequency bands used in telecommunications—up to 88 *terahertz*.

The new value was the fruit of two experiments. The first came in late 1971 when NBS scientists made the highest frequency measurement ever with a laser [SNF, Apr. '72]. The next step was to measure the wavelength of the same laser emission. Multiplying the frequency by the wavelength gives *c*.

For the past 15 years, scientists and engineers had to make do with a value for *c* of 299,792.5 kilometers per second. The new value is 299,792.4562 km/sec., plus or minus 1.1 meter per second. For those not yet metrified, that's 186,282.3960 miles per second, plus or minus 3.6 feet per second.

Tagging the oil spillers

The world's oceans and other waterways are continually subjected to pollution from oil spills. Some are accidental, but many come from tankers discharging oil in violation of marine laws. Because it is almost impossible to trace the guilty vessel from the oil spilled, most violators go undetected, and the taxpayer is saddled with the cleanup bill when the spill creates a mess—about $10 a gallon in American coastal waters.

But now there's a way to track down the oil spillers. Scientists at General Electric Research and Development Center propose seeding oil shipments with a batch of magnetic metal dust, as pictured here. Each batch would have a different Curie point—the temperature at which magnetic properties disappear. And these values could be coded and

registered for each shipment. When a spill occurred, the metallic "tags" could be picked up by a magnetic sled floated through the oil slick, and a simple anal-

Continued

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Here's what Myra Waldo wanted to know about her new General Electric microwave cooking center.

Myra Waldo has written more cookbooks than any other person. Some of her most popular cookbooks include: *The Complete Round the World Cookbook, Myra Waldo's Chinese Cookbook* and *The Complete Book of Wine Cookery.* Miss Waldo's questions about microwave cooking are part of a continuing series answered by General Electric.

Q. How does microwave cooking differ from conventional cooking?

A. In conventional cooking, the air or liquid surrounding the food is heated and heats the surface of the food. This heat is conducted into the interior of the food and cooks it. In microwave cooking, the microwave energy is absorbed only by the food and does not heat the surrounding air. This energy causes the food molecules to vibrate against each other, resulting in friction and creating heat which is conducted through the food and cooks it faster. General Electric markets two complete microwave cooking centers (Model J896 and Model J856), plus a countertop portable microwave oven (Model JET80). Cooking speed varies with the type of food being prepared, but here are some comparison times:

FOOD	CONVENTIONAL COOKING TIME	MICROWAVE COOKING TIME
Chili	35 Min	15 Min
Thaw Frozen Fruit	10 Min	2 Min
Lasagna	45 Min	17 Min
Stuffed Peppers (6)	60 Min	22 Min
Brownies	25 Min	9 Min
Salmon Loaf	60 Min	14 Min
Scalloped Potatoes	90 Min.	21 Min

Q. Can I put something from the freezer directly into a microwave oven?

A. Yes. Frozen vegetables (even those in cooking pouches), frozen package entrees and home-frozen dishes can all be prepared quickly and easily with microwave energy. You can soften ice cream or butter to serving consistency in only a few seconds. Meats, depending on size and thickness, generally take only minutes to thaw.

Q. Can I make pastries in my microwave oven?

A. Yes. You can expect excellent results with General Electric's complete microwave cooking centers because they have heating elements to provide the conventional heat for browning, while the microwaves provide the speed in cooking. Our portable microwave oven is very effective for pastries which do not require a brown crust for appearance, such as brownies.

Q. When foods are cooked in liquids, does the liquid boil out more rapidly than in conventional ovens?

A. No. There's usually more liquid left because of the shorter cooking time. In a conventional oven, heat and longer cooking time result in more evaporation of liquids and natural juices.

Q. Will a potato skin turn crisp in the baking process?

A. Yes. By using the combination of microwave energy and conventional heat in the General Electric complete microwave cooking centers, potato skins can become very crisp. However, in our portable microwave oven, the natural moisture in a potato keeps the skin moist, and because of the speed of microwave cooking, the skin does not dry out enough to become crisp.

Q. Can I bake a souffle in my microwave oven?

A. Yes. You can create superb souffles with a General Electric complete microwave cooking center because it supplies conventional heat for browning at the same time the microwaves are baking the souffle. Again, our portable microwave oven does not provide a browning element necessary for souffles.

Q. Does a microwave oven require any special electrical installation?

A. No. The total connected load of a General Electric complete microwave cooking center is about the same as required by comparable electric range models. Our portable microwave oven requires only a standard 120 volt, 15 ampere grounded outlet.

Q. Is my microwave oven self-cleaning?

A. Yes. General Electric's complete microwave cooking centers feature our P-7® Total-Clean™ oven, because they also have a conventional oven and conventional heat bakes on food spills and splatter. The surfaces inside our portable microwave oven remain cool enough so food soils don't bake on. You can clean them easily with a damp cloth.

Q. Can I get my microwave oven serviced easily, should I ever need it?

A. Yes. General Electric's Customer Care Service Everywhere goes with every microwave oven we sell. It's our pledge that wherever you are, or go, there's a qualified GE serviceman nearby.

If you'd like to know more about microwave cooking, write: General Electric, Dept. M.O., Ap4-206A, Appliance Park, Louisville, Kentucky 40225.

Microwave cooking... another reason why General Electric is America's #1 major appliance value.

Number 2 in a series.

GENERAL ELECTRIC

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ysis could even identify the offender on the spot.

Fusion progress

In Dr. Edward Teller's article for us on the prospects of power from nuclear fusion [PS, May '72], he called the method based on the tokamak principle —originally proposed by the Russians— "the arrangement considered with the greatest hope for effective fusion." Now the Atomic Energy Commission reports what it terms "a major advance" in fusion research from the Adiabatic Toroidal Compressor (ATC), the newest fusion experiment—and one that is based on the tokamak concept—at the AEC's Princeton, N.J., Plasma Physics Laboratory. The advance is twofold: The ATC achieves for the first time a plasma (very hot gas) density comparable to the range needed for a tokamak fusion reactor to work; and its plasma pressure (the product of density and temperature) is several times higher than that achieved at any of the world's other tokamak devices.

The ATC cycle begins when an electric current is induced in a doughnut-shaped deuterium plasma. This current helps to confine the plasma and also heats it. At this stage, the electrons in the plasma reach a temperature of about 10 million degrees C. Next the plasma is compressed by a pulsed magnetic field (the pulse or shock is the "tok" in the Russian word "tokamak"). This raises the electron temperature to 25 million degrees, and the density of particles in the plasma reaches 100 trillion per cubic centimeter.

This temperature is still far short of what will be needed in a successful fusion reactor, however: an ion temperature of about 100 million degrees C. According to AEC Chairman James R. Schlesinger: "We still have many years of hard work ahead of us to develop this concept into a practical power system."

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First atomic refrigerator

That's a nuclear fuel capsule with plutonium 238 being lowered into a re-

frigerator—the world's first to run on atomic energy. The cryogenic unit was originally designed by Hughes Aircraft to supercool laser and other devices; it ran on electricity. But for spacecraft applications, a long-lasting, self-contained energy source that made no demands on the vehicle's limited power supply was desirable, so the Atomic Energy Commission developed the nuclear technology demonstrated now. This unit could run on the heat of decaying plutonium radioisotopes for 88 years without refueling.

Avian altimeter

A minute altitude recorder has revealed that birds can fly to unsuspected heights. Developed by Swedish researchers, the altimeter, which weighs less than a gram, consists of a tiny plastic vial containing radioactive polonium, and a plastic detector. The polonium's radiation marks the detector strip—the higher the bird carrying it flies, the greater the marking. Reason: Air density drops with increasing altitude, and the intensity of the radiation is reduced by the intervening air layer. Swedish swifts equipped with the new altimeter have registered flights to more than 12,000 feet above sea level, and even carrier pigeons have gotten mile-high. PS

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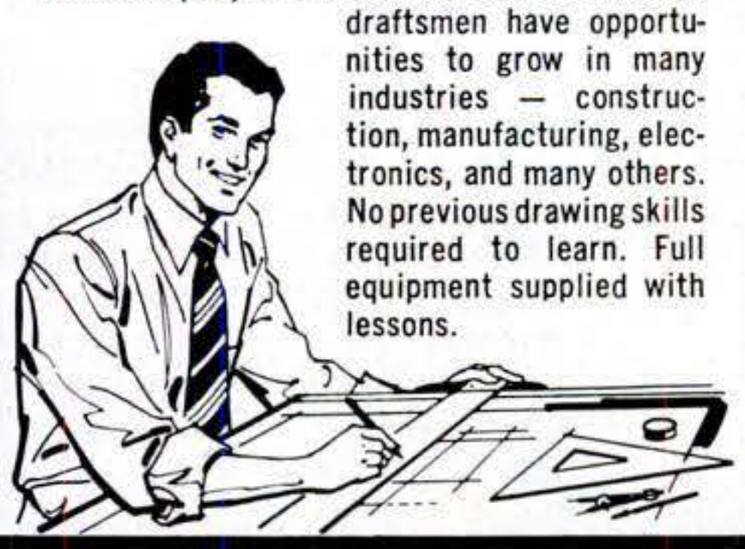

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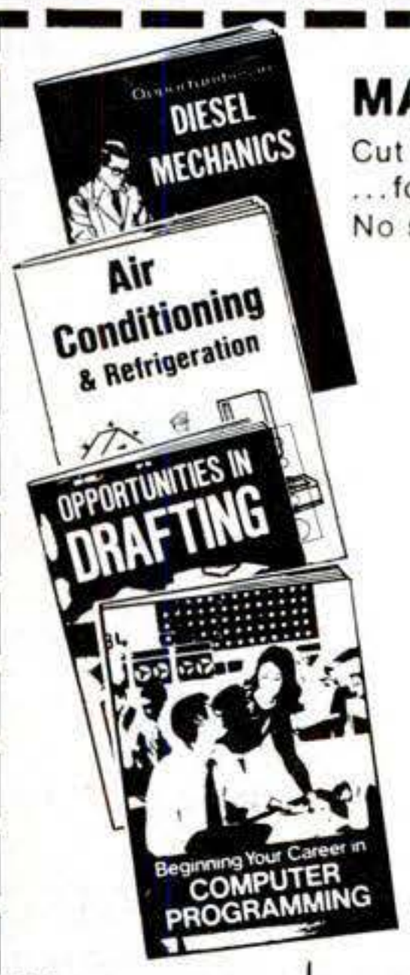

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Detroit Report...

By JIM DUNNE / *PS Detroit Editor*

GM will go 80 to 100 percent Wankel

That's what John DeLorean said at a GM management meeting (the former Pontiac chief engineer and Chevy general manager is now group vice-president for cars and trucks). How soon could GM convert to the Wankel engine? Within 10 years, he said. Of course, it's important to understand that GM has a multitude of proposals for the rotary engine, and DeLorean was talking about one extreme. He pointed to the smoothness and quietness of the engine, but also revealed that a single-rotor Wankel could be up to $70 cheaper than the Vega four-cylinder engine; and a twin-rotor Wankel could be $60 cheaper than a V8. Cost savings of this magnitude practically guarantee high production of the GMRE, even if enormous investments in new factories and machines must be made first.

Wankel-powered FWD Chevy-Van

President Ed Cole told key executives that GM is weighing plans to put the GMRE into a new-model Chevy Van with front-wheel drive. The drive train would be a simple adaptation of the one planned for '76-GM compacts. Front-wheel drive makes even more sense in a van than in a sedan.

Rear-drive types of vehicles with front engines have wheelspin problems and poor front/rear brake balance when running lightly loaded. With front drive, the loading floor can be lowered since clearance for the drive shaft is no longer necessary.

European auto makers started to build front-drive vans in 1941.

Front-drive vans are now produced by Renault, Citroën, Peugeot, Fiat, Alfa-Romeo, and Mercedes-Benz. But GM could be first with a Wankel-powered version. It would give easier servicing, lighter weight, and reduced drive-train vibration. Reports say the new Chevy Van will be narrower but longer than the present model. Target date was set for '76, but this is dependent on the timetable for the rotary-powered sedans.

GM halts work on piston engines

For the first time in memory, General Motors is without a single program aimed at the creation of a new piston engine. While intensive development work on existing engines goes on, to meet '75 and '76 emission-control standards, all engineers formerly assigned to basic engine research have been pulled off the job. This situation may be temporary, but it is clear that while a major effort is going into perfecting the rotary engine, GM is spending no money on new piston engines. All experiments with light alloy blocks, overhead-cam V-8s, and automated assembly lines have been stopped. It looks more and more like GM has made its choice, and the winner is: The GM Rotary Engine.

'74 Mustang will be part German

Next year's Mustang will be based on the Pinto chassis, and Ford plans to import the German-built V6 engine as an option over the basic fours. That's the same V6 now used in the Capri. The '74 Mustang engine lineup looks like this: 2000cc OHC four, 2300cc OHC four, and 2600cc OHV V6. Ford plans to install the V6 in about half the Mustangs, or up to 200,000 per year.

Electronic ignition makes it big

Ford and General Motors will follow Chrysler, offering electronic ignition systems on a wide basis in '74 models, especially those marked for sale in California. Ford plans to equip its 1974 California emission-test fleet with electronic ignition and catalytic converters to prove out its '75-'76 emission control. GM will put its unitized ignition system (now a Pontiac exclusive) on some Cadillacs this year, as a running change. Then its use will be expanded to Buick and Oldsmobile during the '74-model year. Pressure from dealers will speed the process. GM and Ford retailers are screaming about the advantage Chrysler has with its electronic ignition (standard on all '73 models).

Chrysler turbine is alive and well

Once Chrysler held a commanding lead in gas-turbine development, then watched it slip away as Ford and GM announced their production turbines (truck and industrial). Now Chrysler is back in the race again. Chrysler was awarded an $8 million contract from the Environmental Protection Agency to build a gas-turbine automobile providing low emission levels, good fuel economy, and long life. Chrysler will start with its sixth-generation turbine (the first went into a '54 Plymouth) and gather together all the advances made by other government contractors for refinement into a final design.

Can Chrysler leapfrog the Wankel?

One Chrysler insider was so jubilant about the turbine contract that he revealed his company might be able to jump right over the Wankel engine and have a turbine ready for a production car in the early 1980s. That would be a miracle. Despite a mass of new materials for turbine wheels and other critical parts working in super-heated areas, no low-cost solution has been found. The gas turbine is still three to five times more expensive than a V8.

GM to import minicar from Japan

Isuzu Motors in Japan (35 percent owned by GM) has decided to build a new plant for production of a new small car now under joint development by Isuzu and General Motors. Reports say the car has a 1200cc four-cylinder engine and is capable of meeting future U.S. emission-control standards. This new car will compete in the fast-growing lowest price segment of the U.S. market with Toyota, Datsun, Fiat, Honda, Subaru, and possibly more cars from Japan. Ford is also developing a small car that may show up in this market about the same time as the GM/Isuzu job.

Wankel engine moving to Camaro?

Last May I reported that GM would start building rotary-powered Vegas in the '74 model year. Last August, GM confirmed this. Now it is beginning to look like GM will change the program, due to a complete redesign of the Camaro. The '75 Camaro will be all-new, with the Vega chassis as its base. The Vega SOHC four will become the standard engine. Now, a last-minute proposal is to provide it with a twin-rotor GMRE as an option, and use this model for the GM rotary to make its debut. That makes sense. The Camaro will need something extra to maintain its sporty image when it goes to the smaller size.

Many GM V-8s to be dropped soon

GM's plans to cut down on the variety of V8 engines it builds took a big step forward when executives discovered the conversion cost involved per engine type to meet the '75 standards. It means completely new carburetors, induction systems, and exhaust manifolds, in addition to catalytic converters that are common to all engines. Now there's a push to eliminate some engines. Pontiac and Oldmosbile V8s could be replaced by engines made by Chevrolet and Buick. Eventually, by long-standing plan, all GM passenger-car engines would come out of Chevrolet and Cadillac. That way, GM will be able to offer one V8 in each size and eliminate wasteful duplication. Increased activity on the GM rotary engine could speed this elimination process along even faster.

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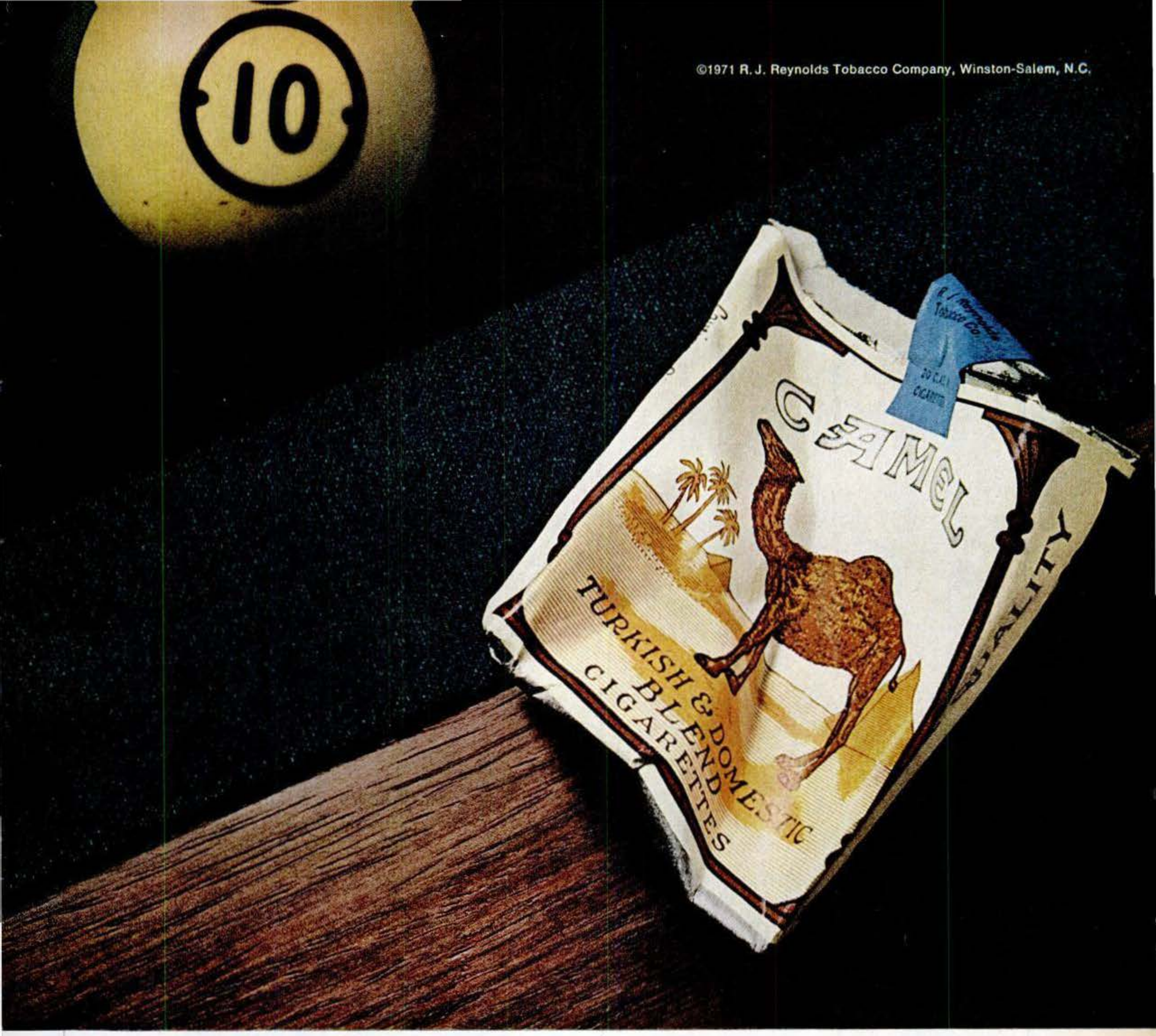

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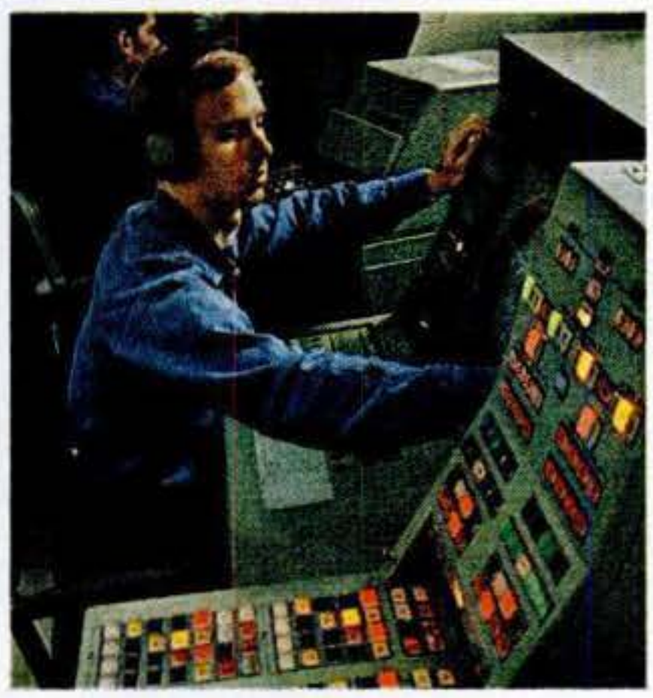

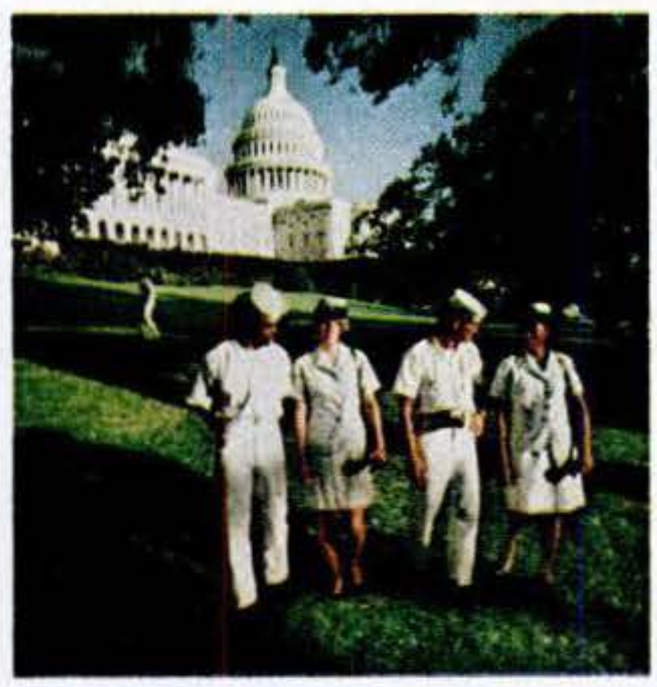

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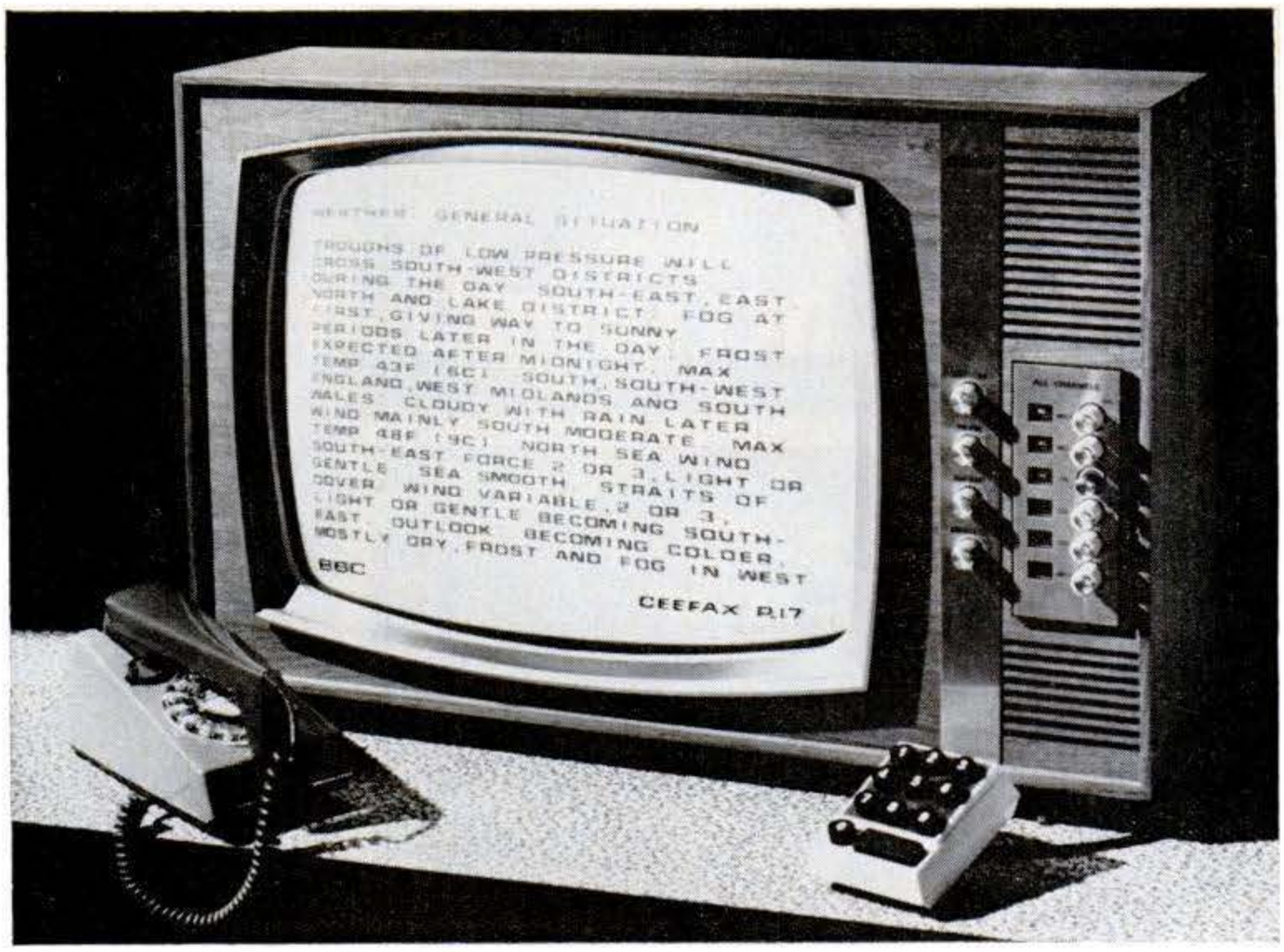
Look and Listen

News, comment, and opinion from the world of home-entertainment electronics

By C. P. GILMORE



Push the buttons to get more from your TV

What can you watch besides Marcus Welby, Flip Wilson, and the evening news? If a new BBC device called Ceefax goes into operation, you'll be able to punch a button that wipes out the regular program and gives you up to 30 printed pages of weather reports, sports results, program announcements, stock-market prices, and other information.

TV stations would broadcast the regular shows plus all these other services simultaneously. The extra information would be shoehorned into the tiny gaps that occur 60 times a second as the beam finishes painting its picture on the tube and flies back up to the top to start over. With a pushbutton unit like the one above, you'd call up any of the available information. The system is expected to be in production in England in two or three years and sell for around $120. So far, no U.S. plans.

Video-cassette scorecard

Sony continues to pull ahead in the video-cassette-recorder sales race. The big Japanese company has made 30,000 of the units so far, of which 20,000 have been sold in the United States; has a backlog of 20,000 orders; and expects to make and sell 100,000 during 1973.

Sony's strategy of going after the industrial, educational, and commercial market has certainly paid off. But further down the road the company hopes to make a big splash in the home-entertainment field, too. Sony President Akio Morita says that a simplified version of the U-Matic machine will become a mass-consumer product in about five years. The marketing goal will be a million units a year, and price should drop from the present $1400 to under $500.

Morita also says that video discs ["Laser Plays 45-Minute Video Disc," PS, Dec. '72] "are likely to become important in coming years, too." He says Sony is working on one, but has nothing it wants to show at this time.

Cartrivision—going strong

While Sony has built more video-cassette machines than anyone, Cartrivision holds a clear lead in the consumer market. The company has announced that Warwick (which makes sets for Sears) and Teledyne Packard Bell have ordered another 5500 decks.

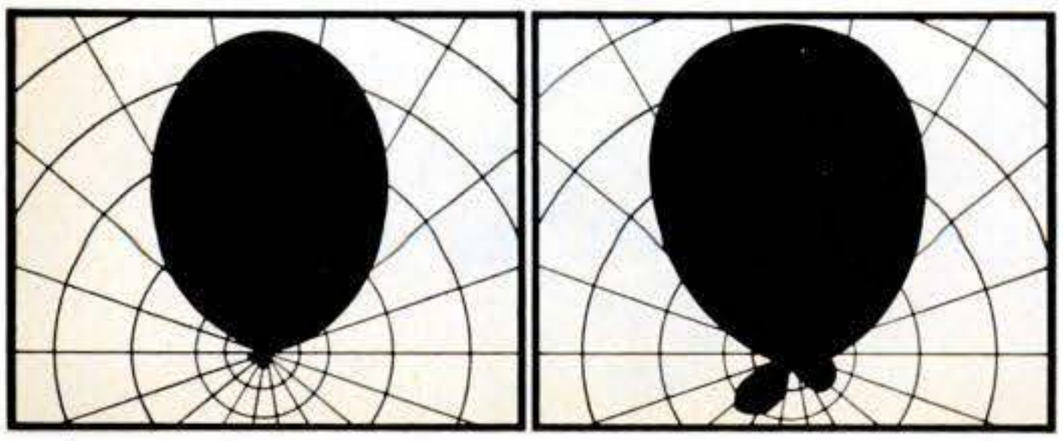
Most surprising finding: In surveys, only one out of four people say they would buy an accessory TV camera (an extra $250) if they bought a Cartrivision unit. But Warwick and Packard Bell ordered 2000 new cameras with the 5500 decks. When customers get eyeball to eyeball with a Cartrivision unit on the sales floor, and when they're already putting out something like $1400 for the combination unit anyway, nearly one out of two buyers spring for the extra $250.

The antipollution antenna

For years, TV-antenna makers have been bragging about supergain antennas that snag signals from great distances. But with nearly everybody now within easy range of a station, sensitivity isn't the problem. The big hangup, as Len Buckwalter pointed out [PS, Nov. '72], is TV interference, which puts hash, bars, flashes, and other annoying marks on your screen.

Now it looks as though antenna makers are attacking electronic pollution. For example, the Channel Master Quantum looks pretty much like any other antenna, but the diagrams below tell an interesting story.

Those blobs are field-strength patterns. They show two antennas' relative sensitivity in all directions. The big blob out front is the antenna's primary pickup lobe—that's the side of the antenna aimed at the TV station. Interference frequently comes from the back or the side. The smaller those rear lobes, the better the antenna rejects interference.



Compare the pattern at right, a typical antenna, with the one at left—the Quantum. The Quantum's high front-to-back ratio should mean excellent interference suppression. This is the way antenna design will be going in coming years, I am convinced.

End of an era?

One of the principal names in the high-fidelity industry has been the H. H. Scott Co. But its future appears uncertain. Scott has been in financial trouble since 1968. Suddenly, apparently as the result of a lack of operating capital, the company has closed down all production facilities and laid off all production workers. Company officials haven't commented, but it is reported in the industry that Scott may be sold to a Belgian company, Syma International.

Shove it in your ear

Remember Dick Tracy's wrist TV? Nobody has built one yet. But an English company *has* developed a radio you can shove in your ear. The circuit, developed by Ferranti Ltd. of Manchester, includes an antenna matching unit, RF amplifier stages, a detector, audio-frequency amplifier stages, and an automatic-gain-control circuit—all on an 0.001-inch-square chip. It will sell for about 50 cents to manufacturers who can make it into an earphone radio by adding a tuning capacitor, two small capacitors, and two resistors. No production plans announced yet.

If you don't like it, yell

Convinced your local radio and TV stations aren't delivering the community services they promised to when they got their licenses? The FCC would like to

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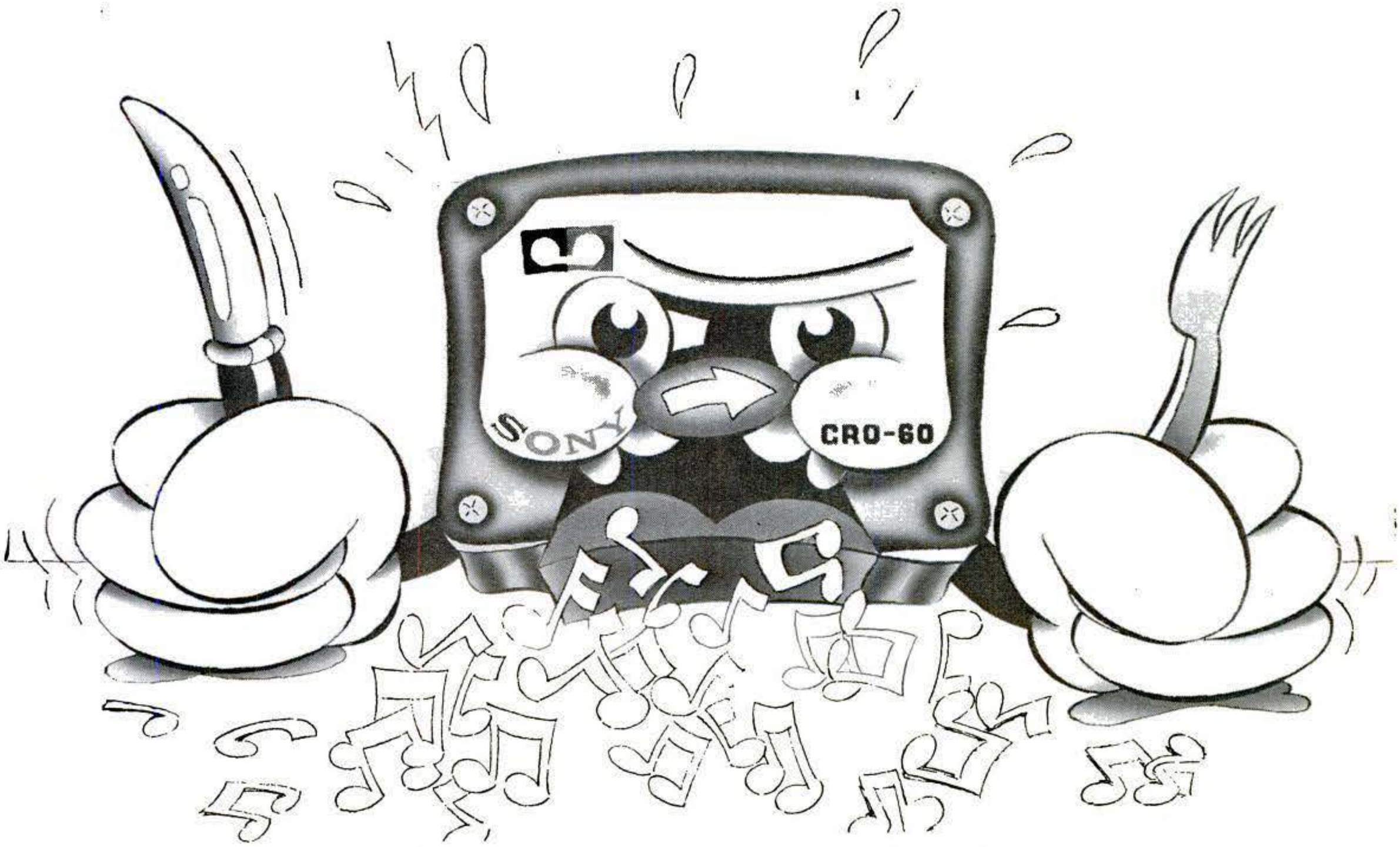
Sony's new chromium dioxide cassette tape is hungrier for high frequencies.



Sony chromium dioxide CRO-60 tape will record up to 50% more volume before you encounter distortion on playback. CRO-60 is hungrier than other tapes for high frequencies.

This means more recorded sound than standard cassette tapes before distortion sets in.

What you hear.

Far less distortion, a smoother frequency response, and a greater dynamic range than standard tape. Every aspect of the sound, especially the higher ranges, comes through with sparkling fidelity.

Sony CRO-60 gets it all together from bottom bass lows to high howlin' highs. And everything in between.

A Sony tape for every purpose.

The new Sony CRO-60 cassette tape becomes a member of a highly advanced line of tapes for every recording requirement.

In addition to standard open reel, cassette, and 8-track cartridge tapes, Sony also offers the finest in high performance tape: SLH-180 Low-Noise High Output tape on 7" and 10½" reels, plus Ultra-High Fidelity Cassettes.

These high-performance tape configurations take advantage of the added performance of today's highly sophisticated recorders by providing wider dynamic range, greatly improved signal-to-noise ratio, extended frequency response, and reduced tape hiss.

How's your appetite?

Now if your appetite has been whetted and you're hungry for more information or a demonstration of CRO-60 or any other Sony tapes, get on down to your nearest Sony/Superscope dealer (he's listed in the yellow pages) and get an earful.

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Look and Listen

[Continued]

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Tape—now even better sound

Open-reel tape already contains some of the highest-fi sound in existence. Now Ampex, which duplicates most of the open reels sold in this country, is making them even better. The company says that selected new releases will be Dolbyized (they'll also be offered in standard versions), which should squelch the last vestiges of hiss.

In addition, all reels—Dolbyized or not—will benefit from a new low-noise high-output tape and new super duplicator electronics, which will together expand the usable dynamic range by nearly six db—an important amount. Ampex says that other new mastering techniques and duplicating advances will improve quality even more. The Ampex II series, says the maker, will be solidly state-of-the-art.

Even thinner

Last November I mentioned TDK's new three-hour audio cassette. The company said the 0.00025-inch tape was the thinnest man-made commercial product it knew of. I asked if readers knew of any thinner.

They did. Edward Howard of Lexington, Mass., sent a sample of calendered kraft paper used in capacitor manufacturing—just 0.00002-inch thick. Stevens Paper Mill tells me it makes 0.00015-inch paper, too. William Robinson of Brownsville, Tex., pointed out that Mylar is also made in these thicknesses.

But the clear winner was Harold Day of Hughesville, Pa., who pointed out what we all should have known: Common gold leaf is far, far thinner. I looked it up in the *Encyclopaedia Britannica* and found that it is an astonishing 0.000007 inch—so thin you can see through it.

Gershwin in Monte Carlo and other matters, reviewed by Arthur Fisher

At the risk of seeming un-American I can't imagine a better set of performances of some Gershwin "serious" standards than those on a new Philips disc by Edo de Waart, a young Dutch phenom, conducting, of all things, the National Opera Orchestra of Monte Carlo. The selections are *An American in Paris*, the *Cuban Overture*, and a "Symphonic Picture" arranged by Robert Russell Bennett from Gershwin's folk opera *Porgy and Bess*. They sound like theater pieces played by a theater orchestra, in perky performances distinguished by lively, intimate sound. The result is a sheer delight.

A new Deutsche Grammophon release of Paul Hindemith music arrived too late for inclusion in last month's batch of discs for audio buffs, but it would surely have ranked high on that list. The *Mathis der Maler* symphony (based on an opera about the painter Matthias Grunwald)—probably Hindemith's masterwork and a marvelous example of colorful orchestral writing—and the *Concert Music for Strings and Brass* are played by the Boston Symphony under William Steinberg. The readings are first-class, and the sonics are extraordinary, including deep, firm bass and very extended dynamic range. Rarely have the massed strings and brass choirs of a great orchestra playing at full tilt been so satisfyingly recorded.

Dvorak's *Legends*, a collection of 10 ingratiating, dance-like pieces, have been undeservedly neglected both on records and in the concert hall. They hardly suffer in comparison to the much-better-known *Slavonic Dances*, which they resemble in being originally composed for piano duet. You can listen to them now in an intelligent, appropriately restrained playing by the London Philharmonic under Raymond Leppard. The sound of the Philips disc is natural, unpretentious, and open.

Beethoven's *Piano Sonata No. 29, Op. 106 ("Hammerklavier")* has represented a formidable stumbling block for pianists ever since its composition—a craggy work of great length, technical difficulty, and "communications problems." It is also one of the very great works of Western art. Rudolf Serkin has now recorded it for Columbia, in what is probably the best interpretation we shall hear for a long time. Unfortunately the reproduction is not up to this high level; the piano sounds pinched and wan.

If you're in the market for a new recording of the Brahms *Violin Concerto*, try a new disc from Philips. Arthur Grimiaux, one of the world's great violinists, plays the solo part with a singing tone and complete command over the subleties of the score. Colin Davis conducts the New Philharmonia, and the balance between his forces and the soloist is just about ideal: Every detail of Brahms' architecture emerges clearly. This is not the most fiery or dazzling version around, but it is one of the most persuasive. The violin reproduces well, the orchestra reasonably so; there is a shade too much bass emphasis.

On the lighter side, how long has it been since you've heard some really cool jazz piano—the old-fashioned kind? Marian McPartland has two winners on the Halcyon label: : *Elegant Piano* (solos and duets with the legendary Teddy Wilson), and *A Delicate Balance* (with Jay Leonhart, bass, and Jimmy Madison, drums). The former has numbers like "Lover Man" and "Just One of Those Things" (in a fantastic duet), and Maid Marian plays both piano and electronic piano—sometimes simultaneously! *A Delicate Balance* has just that, with very wide—but pleasant—separation among the soloists, who are otherwise very much together in numbers including "El Condor Pasa" and "God Bless the Child." PS

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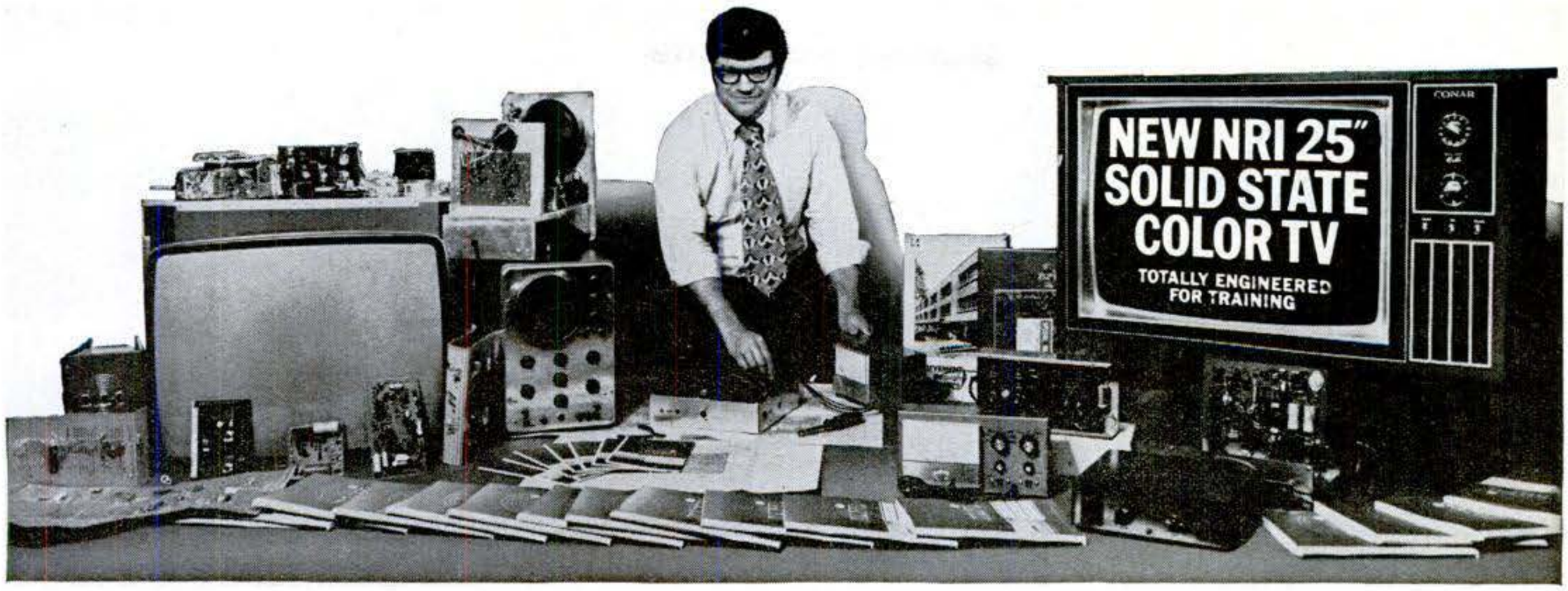

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My problem: I sail a small (13-foot), light (200-pound) sloop with a planing hull. With such a craft every pound counts, and I don't want a heavy outboard along to cut my speed. That's why I sometimes have a long paddle home when the wind dies.

But no more. The 8½-pound AquaBug isn't heavy enough to bother me, so I stick it in a storage compartment where it's handy when needed.

Serving as a lightweight auxiliary is probably AquaBug's perfect assignment. But it can play other roles as well. It's great for a canoe, for example. Not only will this small machine, rated at "one furious horsepower" by the manufacturer, drive such a craft at satisfying speed, but its light weight and simple controls make it easy to install, start, and handle—even aboard a tippy craft.

And AquaBug is a natural for inflatables: It will take up hardly any room in the car trunk next to the folded boat.

The single-finned, air-cooled cylinder and crankcase are cast aluminum with a steel liner in the cylinder. These parts, plus the aluminum drive shaft and exhaust tube, are anodized to prevent corrosion. The crankshaft, connecting rod, and drive shaft are roller-bearing-equipped. The propeller is Lexan, which the company claims is stronger, lighter, and more resilient than steel. Nylatron gears are self-lubricating and rustproof. It all adds up to a quality product.

The fuel tank holds 30 ounces of 24:1 mixture—enough for about two hours of cruising. The owner's manual is small but complete, and includes a list of 497 U.S. agencies that can give service. There's an unconditional one-year guarantee, incidentally, with no charge for labor, parts, or service.

You won't break any speed records with AquaBug, but a small boat will go quite a bit faster than you could row or paddle it, and you'll get where you're going without wearing yourself out. It's made by SeaBorne Systems, 4413 Austin Blvd., Island Park, N.Y. 11558.—*C. P. Gilmore*

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MILT MARION?

1936 was a very good year for a race fan. The very first race on the famous Daytona Beach-Road Course was held.

The purse was 5,000 bucks, and lest you think this was a minor-league affair, remember the price of groceries in '36. This kind of important money attracted a pretty hot field, including: the Indy 500 winner, Bill Cummings; the dirt track champions Bob Sall, Doc Mackenzie and Ben Shaw; Major Goldie Gardner; the Collier brothers, Miles and Sam; and an obscure service station operator named Bill France.

The winner? Good old boy Milt Marion, in a Ford V-8, the Permatex Special. (That France fellow was not only Milt's mechanic, but drove another Ford to fifth place.)

The interesting thing about Milt's car was that the engine was literally stuck together with Permatex products. To prove they worked, the engine was assembled without any gaskets, using our Form-A-Gasket products instead (Form-A-Gasket #1, hard-setting, and Form-A-Gasket #2, pliable-setting). Obviously, it held together.

It really wasn't much of a gamble for Permatex. After all, the company got its start helping Barney Oldfield, back in '09. And today, you'll find Permatex products in service stations, NASCAR garages, and wherever automotive products are sold.

You'll find the same Form-A-Gasket that helped Barney and Milt. And you'll find the latest additions to our long line. Like the new Silicone Form-A-Gasket. With this handy tube, you can actually *make* any size or shape gasket for any application. And being silicone rubber, it is resistant to a greater variety of chemicals, higher pressures, and higher and lower temperatures than anything else you can buy. It is the most versatile adhesive-sealant there is.

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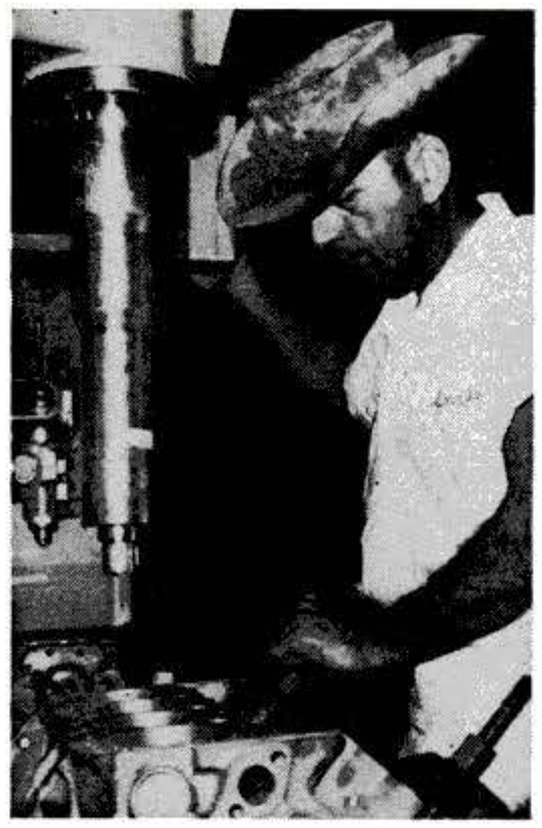
"Say, Smokey—"

A clinic on cars by America's most famous mechanic

Each month in POPULAR SCIENCE Smokey Yunick answers questions on cars—family cars, high-performance jobs, hot rods, and racing cars—selected from those sent in by readers. Got a problem? Send it to: "Say, Smokey—" Popular Science, 355 Lexington Ave., New York, N.Y. 10017. Questions cannot be answered by mail.



My problem is to keep the 289 V8 in my '66 Mustang from stalling when the weather is cold. It starts instantly when turned over but quits within a few seconds unless the gas pedal is pumped constantly. So far I've replaced the fuel pump, filter, and thermostatic spring housing, and adjusted the choke, idle mixture, idle speed, fast-idle speed, and float level to specs. Recently gave the carburetor a gum-out treatment, too. But none of these things helped. Is the culprit something other than the carb? The car runs fine, once warmed up, and delivers an honest 21 mpg on the road. But the lower the ambient temperature, the worse the problem. Help!

BILL WURST, Nashua, N.H.

Your trouble is the lack of vaporization from cold, low-velocity fuel, which is worst at startup, but turns the bend and straightens up after the engine is warm. The type of engine fuel you use is a big factor. Best for cold weather is a fuel with a low vapor pressure. However, the same fuel can cause flooding and stalling in warm weather.

Here are some aids to cold-weather operation without changing fuels: Manifold heat is very important, so make sure the exhaust system is working in regard to heating the intake manifold. Next, an air cleaner can help—or hurt—the problem of cold starting. For example, it could be letting cold air blow right into the carburetor. Maybe you can help in this area. Also, an engine warms up faster with little or no water circulation, so the thermostat and bypass play a big part. Thermostatic fans that don't turn, when cold, help and are readily available. Last, a heated garage, or electric engine heater, could end the problem.

Is it good or bad for an engine to drive a car constantly at the speed of its maximum engine torque? Would appreciate your comments about this.

FLOYD FREEMAN, Staten Island, N.Y.

Maximum engine torque is generally developed at a lower rpm than the cruising speed of a car. Therefore you can't run at maximum torque unless you run quite slow with a load, or with a very low gear ratio. This would be quite uneconomical. Maximum torque and maximum horsepower are not developed at the same rpm. Horsepower is torque multiplied by rpm, and the highest horsepower, generally speaking, occurs quite a bit after the maximum torque.

I had my '72 Ford (400, two-barrel carb) in for its 12,000-mile service and tune-up. When I picked it up I was told I'd better use premium gas or I'll be facing a valve job at 20,000 miles. The manual calls for regular gas, and I've been using Mobil Regular with good results—no pinging. What's your opinion on this?

J. F. ARTHUR, Los Angeles, Calif.

You should get along fine with regular, but I believe your best luck, for the time being anyhow, will be with leaded regular. I believe that you misunderstood the mechanics, and they were concerned about the possible problems with new unleaded fuels.

We have a 1972 Impala with the 400-c.i. engine, two-barrel carb, auto transmission, and all power options. The problem is that when we run at expressway speeds for a while the engine will start to cut out. It first happened when trying to pass another car with the pedal floored. The problem has become worse and now the engine even cuts out at steady speeds. Also, if we step on the gas it almost always cuts out. If we let it rest awhile it starts and runs beautifully for a little time, but the trouble always returns.

The dealer put in a new fuel pump, which helped for about 100 miles, then the stalling returned. The car now has 1300 miles; the trouble started at about 800 miles. We will appreciate any information you can give us, so we can pass it on to the dealer.

DAVID HOHMAN, Bay City, Mich.

You've got a dangerous critter there, and I wouldn't fool around with it. Sounds like after a certain time, or after a time-and-temperature point is reached, either your ignition goes dead or you lose fuel supply.

Fuel is the easiest to check. Have a fuel-pressure gauge installed temporarily just before the carburetor, then drive until the problem starts. If you had fuel pressure while the engine acted up, head for an automotive-electrical technician for a thorough examination of ignition that fails when hot.

One other possibility: If it's practical when the car acts up, even if the fuel pressure is normal, have the top of the carburetor removed for a visual fuel-level inspection. That is, you could have a fuel stoppage in the carb, also. It's not likely, but possible.

Help! I bought a new 1972 Vega and it's always running out of gas. Can another tank be added without too much expense?

BERT DONAHUE, Belvidere, N.J.

Not today. With all the new emission fixes, where would you put it? The only practical thing you can do is have a professional add onto the present tank, and I'd suggest you check the law before doing so. Also, if this is a real problem, write to Chevrolet. They might just have a bigger tank that has escaped your dealer's notice. I say this because I've noticed that some dealers are too lazy to check special questions.

My 1972 Dodge Dart six-cylinder 225 with A/C and power steering won't keep the interior warm during winter months. The engine just doesn't get warm enough to provide hot water to the heater. The discharge air from the heater is 136 degrees F when the outside temperature is down to 30, and it drops as the outside temperature does. A new thermostat did no good, neither did covering the radiator. I can drive 70 mph for 100 miles with no heat. Neither the dealer nor the Chrysler Corp. rep have been any help. Do you have a suggestion, or should I sell the car?

EUGENE DAVIDSON, Wentworth, Wis.

First, by shrouding the radiator and/or the thermostat, get the water temperature up to about 180 degrees F—this won't be hard. Now that you have hot water, the next problem is circulation, so investigate the cause of the hot water not flowing through the heater. My guess is that you'll have to reroute a hose or two. Also look out for air locks. That is, bleed the heater core of any trapped air. Check the circulation if necessary by removing a hose. And last, you need a fan that blows heat around the passenger compartment.

I am equipping my '69 Chrysler for trailer towing and am figuring on adding a transmission cooler to the car. The question is: If I use a cooler that will provide very heavy cooling capacity (for car and trailer weight of about 8500 pounds), what transmission ill might occur in winter, when I'm not pulling the trailer? Is it possible to overcool the transmission?

I. MORDKOWITZ, Brooklyn, N.Y.

It is possible to overcool the transmission oil. The transmission works best and lasts longest at a temperature that gives all parts the best operating clearance. I'm not sure what that temperature is in your car, so I'll guess it's about 200 degrees F. When the temperature is above or under the optimum, clearances are too great or too small to deliver longest working life. So if you do make a mistake, make sure it is on the overcooled side. It's least expensive.

[Continued]

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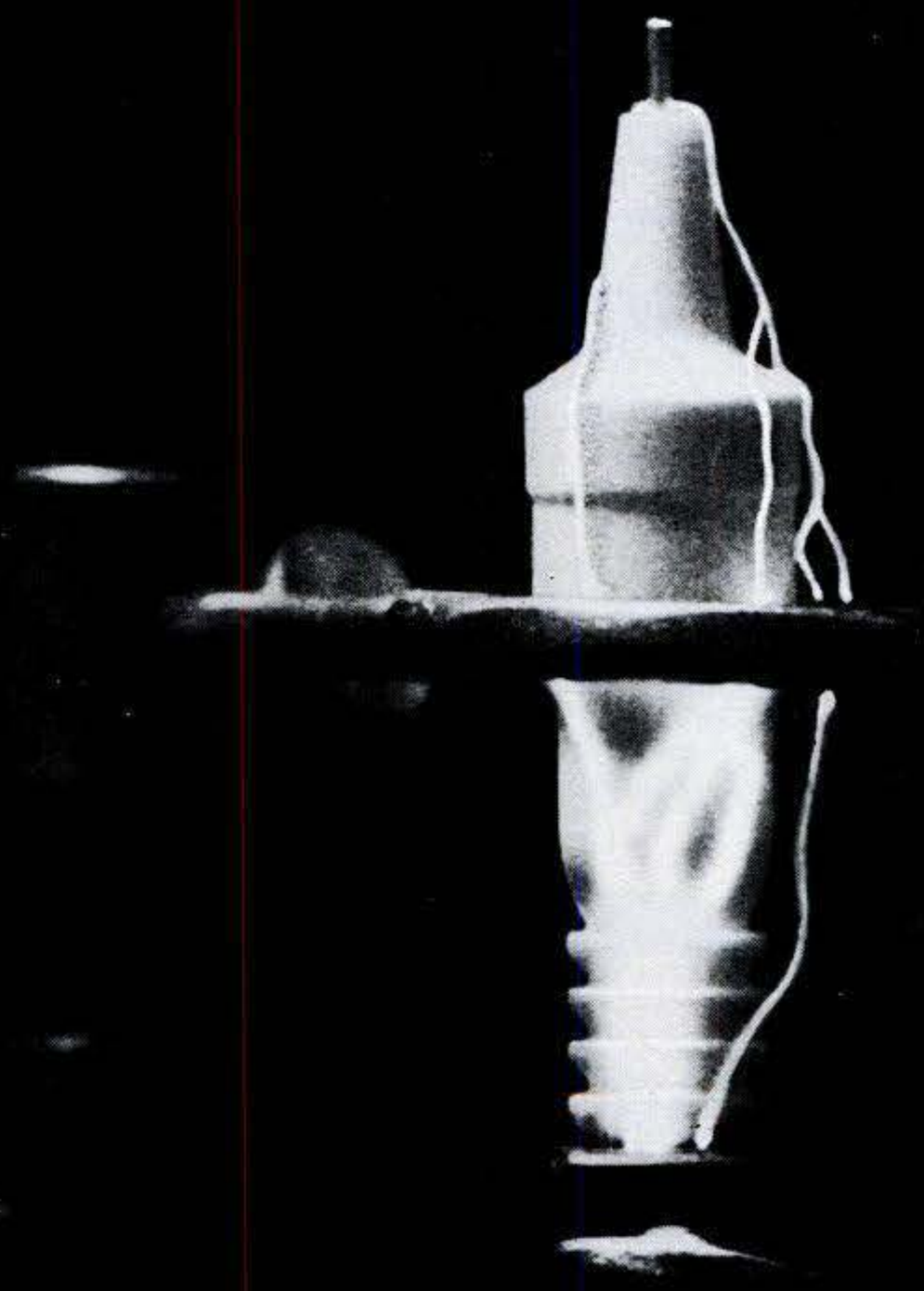
TOUGH!



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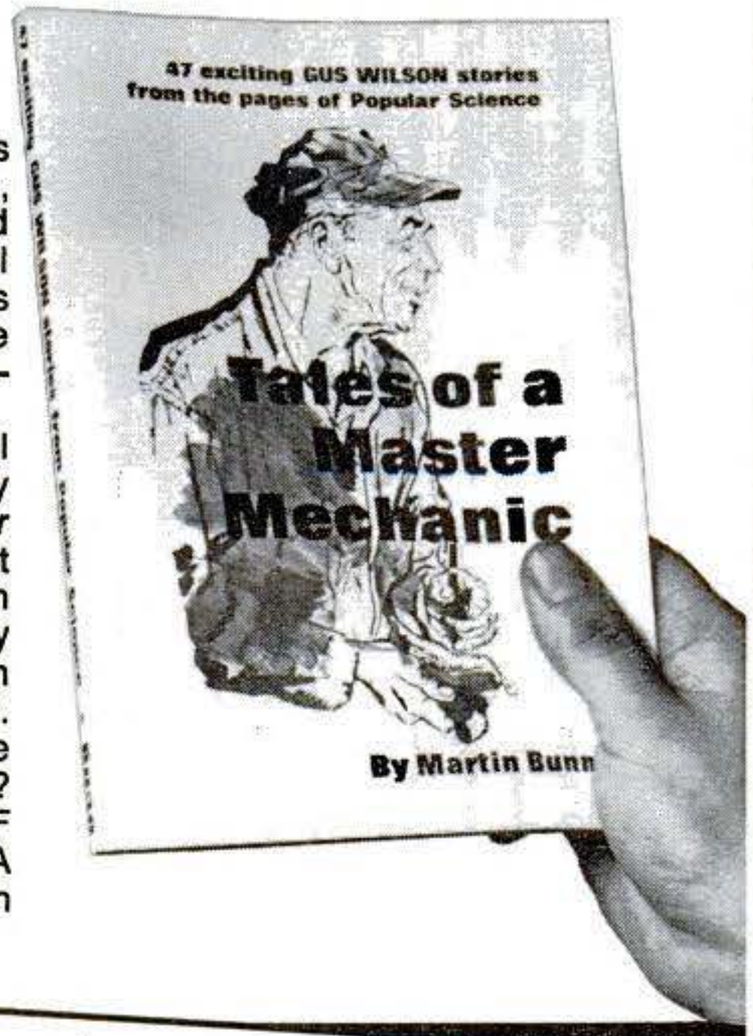

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"Say, Smokey—"

[*Continued*]

There is a very disturbing rear "cluck" in my '69 Buick Le Sabre 400 with 68,000 miles. At my cost, the right rear axle has been pulled twice and the left one three times. Bearings and seals were replaced, right control arms replaced, rear springs replaced with 500-pound overload springs, shock absorbers to a heavier type, axles checked for roundness, and universal joints checked.

Three Buick agencies and two independent repair shops have told me either to trade in the car or just live with the problem. But I have a car here that is neat, clean, and economical, and I would like to keep it, except for the fear of rear-end trouble on the road. One repair man figures the noise could be caused by the splined end of the drive shaft sliding too far forward at times and bumping into the transmission, sending the noise to the rear end. Is this possible?

ANTHONY J. TINTERA, Riverside, Ill.

I believe you'll find your trouble in the drive line at the back of the transmission, as your last mechanic suggested. But it could also be "torque-lock"; that is, as the engine loads the drive shaft, and the axle bounces up and down, causing the drive shaft to get longer and shorter, the drive shaft does not slide freely and releases in jerks, causing a noise I have heard many times. With the car weight on the rear wheels, and the transmission in neutral, get hold of the drive shaft and rotate it right to left, and listen. If you hear the same noise, and have lots of left-to-right play, it could be a loose ring and pinion.

The brake drums won't stay in round on my 1970 Fury III. I've had the front drums turned three times, with linings replaced after the second time. Back drums have been turned once, but still "chirp." The car now has nearly 44,000 miles on it, and all the brake trouble has been during the past year, over approximately 20,000 miles. What's causing this and how can I get it fixed?

RICHARD A. WALKER, Bilkton, Md.

The drums themselves are the trouble. By now you have removed too much metal and the drums are "breathing" under heavy braking, and taking a set. Proper care and feeding of new brakes plays an important part. For example, if you use the brakes in a new car too hard in their new, unseated condition, the linings become glazed and don't hold well. Friction goes up, and the pedal pressure must go up, too, for a good stop. The drum temperature is higher than normal, as is the pedal pressure.

Maybe it's raining and you have to hold the brakes on for a light change, or maybe you pull the emergency brakes on and leave the car. Of course your drums take a set, and there went the ball game —front, rear, or all, depending on the sequence of events. It's going to cost some money, but it looks like you need to start over with new drums, linings, and a good lining break-in. I would recommend factory drums and lining, or a good name-brand lining.

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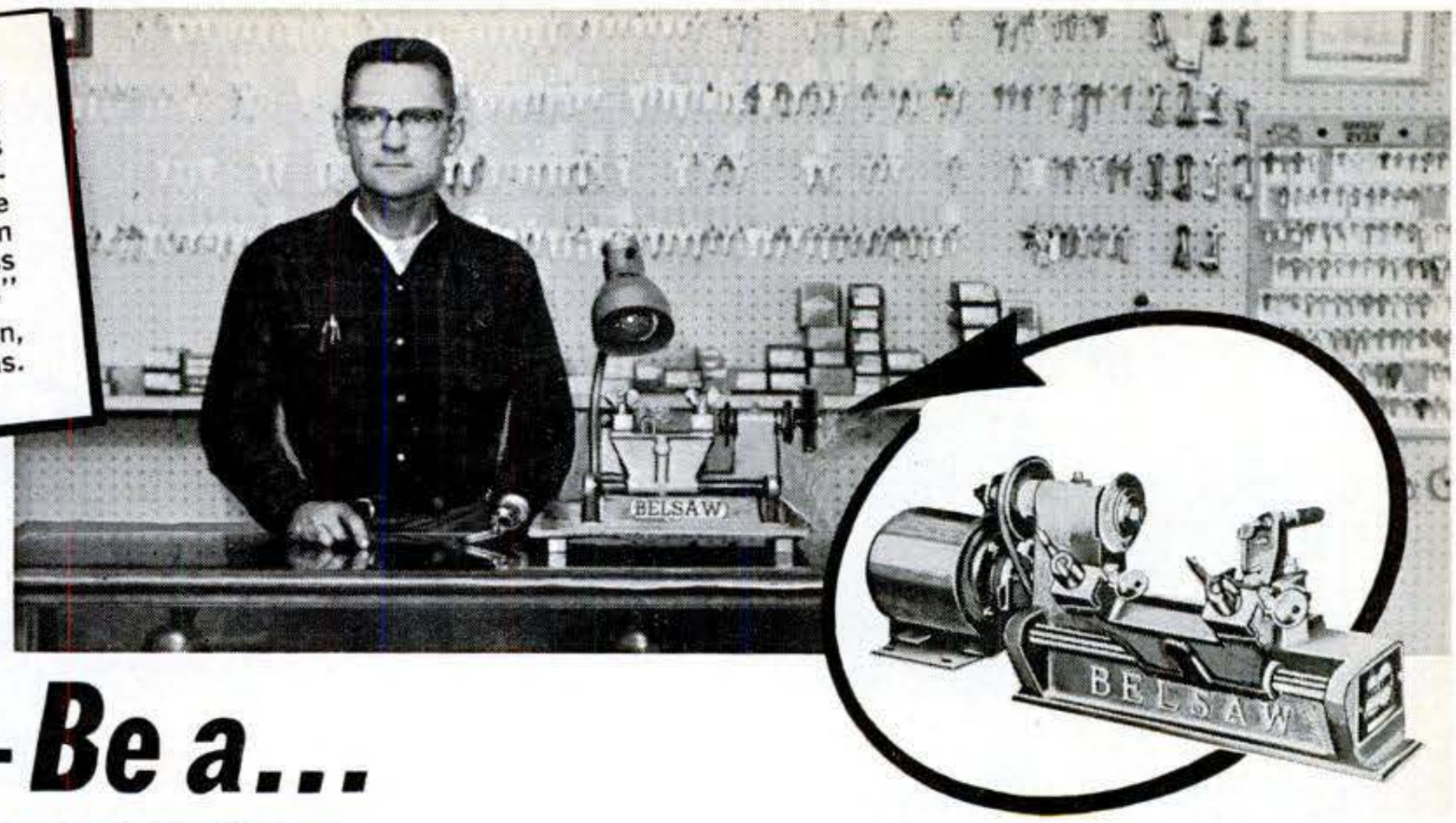

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POPULAR SCIENCE · NORBYE/DUNNE REPORT · CAR TEST

Four birds of a feather in concept and looks, they have surprising differences in performance and road behavior

DELUXE COMPACTS:

Trendy, Lively, and Practical

By **JAN P. NORBYE** / *PS Automotive Editor* **and JIM DUNNE** / *PS Detroit Editor*
PHOTOS BY ORLANDO GUERRA

If you drive a compact, you're a trend-setter. If you don't, you're seeing more and more of them around you. Compacts held eight percent of the market in 1969, and took almost a 14-percent share in 1972. We think they'll be even more popular in '73, for two principal reasons:

1) Compacts are cribbing clever body arrangements from small cars, such as hatchbacks and folding back seats, for the two-door fastback or semi-fastback models.

2) Auto makers have finally discovered that people don't equate size with value, and are beginning to offer luxury versions of compacts.

For our first test of the '73 compacts we chose the trend-setters: Oldsmobile Omega, Dodge Dart Sport, Mercury Comet Custom, and AMC Hornet Hatchback (left, top to bottom). A later test will cover four-door family compacts.

Even though these cars are small by U.S. standards, you don't give up the big-car ride, ease of driving, V8 performance and quietness. You give up very little in front seating room and comfort. The biggest drawback is lack of rear seating space (in sharp contrast to four-door versions of the same models). Rear-seat dimensions are marginal, and ease of entry to the back is generally poor. If you usually carry adults in the back, these cars are not for you.

The test cars were equipped with the small V8 engines, automatic transmissions, and power steering. We also requested power front disk brakes and radial-ply tires. Disk brakes aren't available on the Comet and Omega. (You can't even get power brakes on the Comet.) Power brakes are offered on the Hornet, but our test car came through without a booster. Radial tires are not a factory option for the Dart and Omega. The discrepancies

Continued

PS Ratings—Test Report in a Nutshell

Last month we introduced the PS rating system for the cars we test. It will enable you to make valid comparisons faster, pinpointing strong points and weaknesses. *Ratings are all based on facts:* test results or actual measurements. Opinions or subjective judgment play no part in scoring points. Five points is excellent; 4, very good; 3, good; 2, fair; 1, poor; 0, very poor.

	Hornet	Dart	Comet	Omega
Acceleration	4	4	4	4
Brakes	2	3	3	1
Handling	4	2	4	1
Maneuverability	5	2	5	4
Fuel economy	2	1	1	1
Quietness	1	1	2	2
Ride comfort	(2)	(2)	(3)	(3)
Roominess	3	3	3	4
Visibility	1	1	1	3
Entry/exit	3	2	2	1

How PS tests brakes— and what we learn from it

We test a car's ability to stop within a 12-foot-wide lane from 60 mph without front-wheel locking (rear-wheel locking is allowed, but kept to a minimum). Tests are made first with cool brakes to show brake capacity and balance. Next we make 10 warmup stops from 60 mph at one-minute intervals with 0.5-g deceleration (shown by Tapley meter on car floor). Pressometer on glove-box lid shows pedal pressure. Test stop is repeated with hot brakes to show fade resistance. Final stop is used as basis for ratings:

125 feet or less ..... 5 points
125-146 feet ..... 4 points
146-168 feet ..... 3 points
168-189 feet ..... 2 points
189-210 feet ..... 1 point
210 feet or more ..... 0 points

For test results, see a following page.

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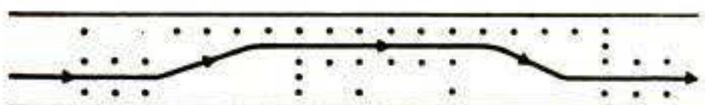
PS handling test simulates high-speed emergency swerve



Two lane changes in quick succession show evasive ability at high speed. Lanes 12 feet wide are blocked 120 feet apart; lane-change gaps are 60 feet long. Speed is increased in several runs until a car's limit is reached (timed by stopwatch). Driving skill has been found to play no part in results, as a car's top speed is limited by some inherent characteristic (excessive understeer, oversteer, drifting, slow response, or slow-geared steering). Above, Dodge Dart Sport is two-thirds of way through grid, with tail end breaking away, and countersteering—note left steering angle despite the fact that the car is moving from left lane to right.

Rear wheels carry only 39 percent of car's static weight. In this situation, there is strong weight transfer from right-rear to left-front wheel, and the left-rear loses its sidebite. Dart's top speed was only 56.3 mph; Hornet and Comet reached 64.7, helped by radial tires. Omega was slowest at 54.5 mph; excessive slip angles on all four tires delayed return to the right lane. Ratings are based on speed through the grid:

65 mph or more .....5 points
61.875—65 mph .....4 points
58.75—61.875 mph .....3 points
55.625—58.75 mph .....2 points
52.5—55.625 mph .....1 point
52.5 mph or less .....0 points

in the specifications chart are due to nonavailability (and a production-program error).

Acceleration and fuel economy. We make three different acceleration tests: 0-60 mph to show the time needed to go from standstill to highway speed, 0-80 to show high-speed power reserve, and 25-70 mph to show passing ability and highway-merging ability. The Comet was best, Omega last. Gas mileage is tested by fitting a one-gallon tank feeding directly into the fuel pump, with the regular fuel system disconnected, and driving around Bridgehampton race circuit at a constant 45 mph until the gallon is gone. Our fifth-wheel odometer records the distance to three decimals. The Hornet was best, Omega last.

Our acceleration ratings are based on the 0-60 mph test alone. We feel that any car that can go from rest to 60 in 11 seconds or less has ample performance, and that more than 20 seconds would not be safe for highway merging. This is the scale:

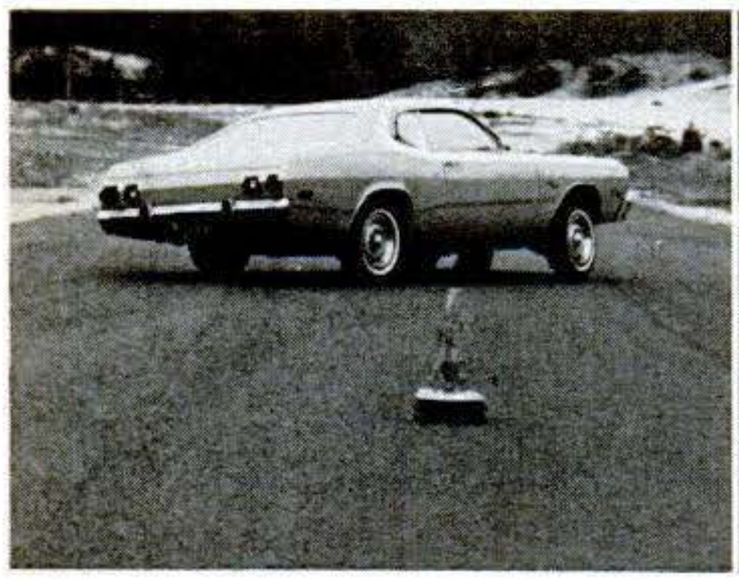
11 seconds or less .....5 points
11-13 seconds .....4 points
13-15 seconds .....3 points
15-17.5 seconds .....2 points
17.5-20 seconds .....1 point
20 seconds or more .....0 points

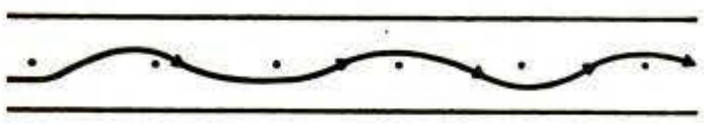
The gas mileage ratings cover the area 12.5 to 27.5 mpg. Why those numbers? Because we know from experience that anything lower than 12.5 mpg is unnecessary, even for a full-size car. And 27.5 mpg is consistent with economy-car owners' claims and buyers' expectations. The scale:

27.5 mpg or more .....5 points
23.75 to 27.5 mpg .....4 points
20 to 23.75 mpg .....3 points
16.25 to 20 mpg .....2 points
12.5 to 16.25 mpg .....1 point
12.5 mpg or less .....0 points

Continued

PS maneuverability test—and what it shows





Simulating a low-speed emergency swerve—snaking a car as fast as possible through pylons 48 feet apart—tests maneuverability. It's a severe test of the entire steering system. We make several runs with each car, progressively faster until top speed is established (stopwatch-timed).

Above left, the tail of the Dodge Dart swings wide, holding speed down to 23.9 mph. Such oversteer can be a help on sharp turns, but Dart's power steering could not keep up with the steering-wheel input (pump catch). At right, the Hornet tracks in stable fashion to record 26 mph.

Fastest car in this test was the Comet (27.2 mph); the Omega reached 25.3 mph. Results demonstrate superiority of radial tires (on Hornet and Comet). Omega had strong understeer, which held speed down in this test. The ratings are based on speed through the grid:

26 mph or more .....5 points
25-26 mph .....4 points
24-25 mph .....3 points
23-24 mph .....2 points
22-23 mph .....1 point
22 mph or less .....0 points

Smaller cars are usually faster, since they have narrow tracks and therefore make less severe directional changes. However, if a car fails to reach 26 mph in this test, it is not due to size but to such factors as turn diameter, steering ratio, returnability, weight distribution, or other mechanical deficiencies.

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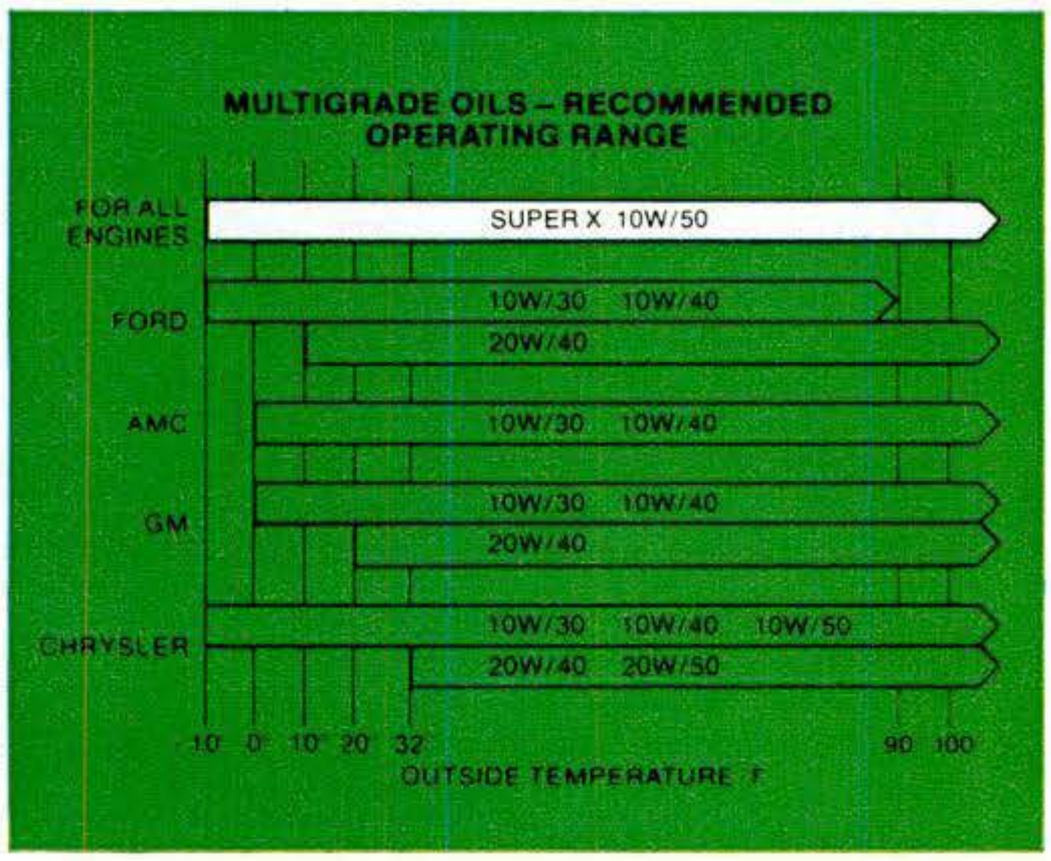
"Super X... better high-temperature protection than any other all-season motor oil."

Stanley Sprague,
Manager, Engine Lubricants Research & Development
Shell Oil Company

"What we set out to develop was an oil that would get on the job fast, when the engine's cold—like an SAE 10W—and then *stay* on the job when the engine's hot—like an SAE 50. SHELL SUPER X® 10W-50 is that kind of an oil.

"Of course, a single-grade 10W will flow as fast as Super X. The trick is to combine fast flow at low temperatures with top protection at high temperatures. This is where Super X stands alone.



Multigrade Oils – Car Manufacturer's Recommended Operating Ranges. Super X covers the extremes of outside air temperatures.

"What I mean about an oil staying on the job is this: You can pretty well assume that all 'SE' API Classification oils give good protection against sludge, varnish, corrosion, oxidation, rusting, and usual wear. However, use of an oil that thins excessively in service can be asking for trouble.

Super X is a breakthrough in motor oil.

"By blending our new viscosity index improver with high-VI base oils, we've developed a motor oil that does not thin down as far as other multigrade oils. Super X simply stays thicker.

"Look at it this way. When starting up cold, Super X gives the advantages of an SAE 10W—fast cranking, fast circulation and low drag.

"When the engine's really hot, Super X stays thicker than any other multigrade oil, and delivers outstanding high-temperature protection.

"Super X meets or exceeds all automotive manufacturers' service fill requirements, as well as the American Petroleum Institute's 'SE' service classification required for warranty protection of new cars. These are the highest ratings required for current motor oils.

"But plenty of motor oils have earned these ratings. Including our own SUPER SHELL® 10W/40 Motor Oil, Shell X-100® Multigrade 10W/30 and SHELL X-100 single grades.

"The point is, Super X gives you a far broader range of protection than any single-grade motor oil—and better high-temperature protection than any other all-season motor oil."

Shell products perform

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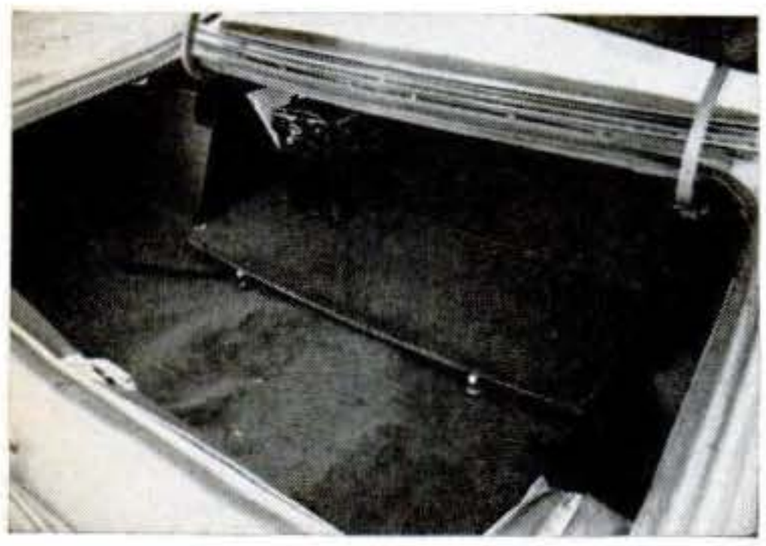
Omega hatch gives huge opening to flat, carpeted floor. Rear seat folds forward to form a useful load platform.

Comet has small trunk and over 30 inches' liftover height. Spare wheel takes most of the floor space. Back seat is fixed.

Hornet hatchback has big opening, but spare wheel takes up valuable space and back seat does not fold completely flat.



Dart Sport has roomiest trunk, highest liftover. Rear seat folds forward; is protected by security panel in UP position.

Our comments on drivability are based on hundreds of miles of highway driving plus a week of city and suburban use. The Dodge evidenced much lumpiness during part-throttle acceleration and occasionally even at constant speed. The Comet had a habit of stalling on turns (slow U-turns, or sharp street corners) at low speed with low throttle opening. Hornet and Omega had no apparent drivability problems.

Brakes. The brake-test results appear in the chart, but to complete the picture, we wish to point out that the Omega and Comet exceeded one-g deceleration with cool brakes, but the GM car fell to 0.9 after warmup, and the Ford product to 0.84g. Pedal pressure during the warmup stops (with 0.5g deceleration) went from 20 pounds to 50 in the Omega, from 72 pounds to 90 in the Comet. The Dart reached 0.98g deceleration with cool brakes, 0.92 after warmup. Pedal pressure doubled during warmup—22 to 44 pounds. The Hornet stopped better with warm brakes (better than 1g) than cool (0.87g), mostly due to rear locking prior to warmup. But fade resistance was exceptionally good: Pedal pressure rose from 65 pounds in the first warmup stop to 70 pounds in the tenth.

Ride comfort and noise levels. We test noise levels in the front seat under three sets of conditions, and rate quietness according to a formula that gives 50-percent importance to noise at 60 mph on a smooth road. All readings are decibels on the A scale of our General Radio standard sound meter.

62.5 or less .....5 points
62.5-64.375 .....4 points
64.375-66.250 .....3 points
66.250-68.125 .....2 points
68.125-70 .....1 point
70 or more .....0 points

Our ratings for ride comfort are still tentative, but we are gaining experience fast. Basically, we have a standard test bump, taken at 60 mph. Vertical accelerations acting on the front-seat passenger are picked up by a sensor and recorded on tape, which is played back through an oscilloscope and photographed. From the pictures we establish the full duration of spring deflections, amplitude, and frequency. We've not decided on a final formula, so ride ratings are given in parentheses. However, the fact that they correlate well with subjective judgment is an indication of validity.

American Motors Hornet. One of the most modern cars on the market, the AMC V8 is of recent design with a proven reliability record. The transmission is built by Chrysler, the power steering by Saginaw (Division of GM), and the brakes are Bendix.

The interior is well equipped, and the exterior styling is competitive with the newest from the Big Three. Front seats are low and the instrument-panel hood is high (designer choices that penalize it in our visibility rating!). The rear seat is cramped, and lacks armrests. But the front doors have storage pockets, in addition to a shelf under the instrument panel, and a glove box. Rear windows are flipper type (crack open at the rear edge for air evacuation).

Controls on the instrument panel are well positioned. A temperature gauge is included, and a cowl vent is

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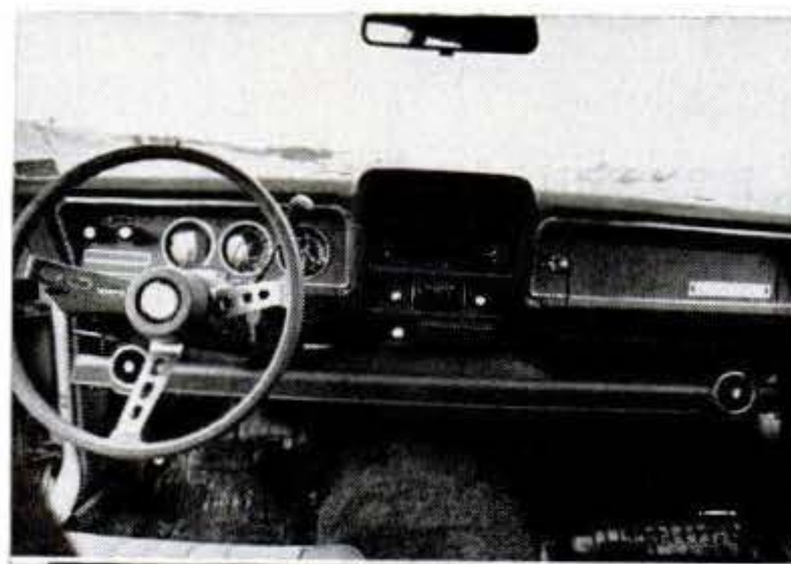

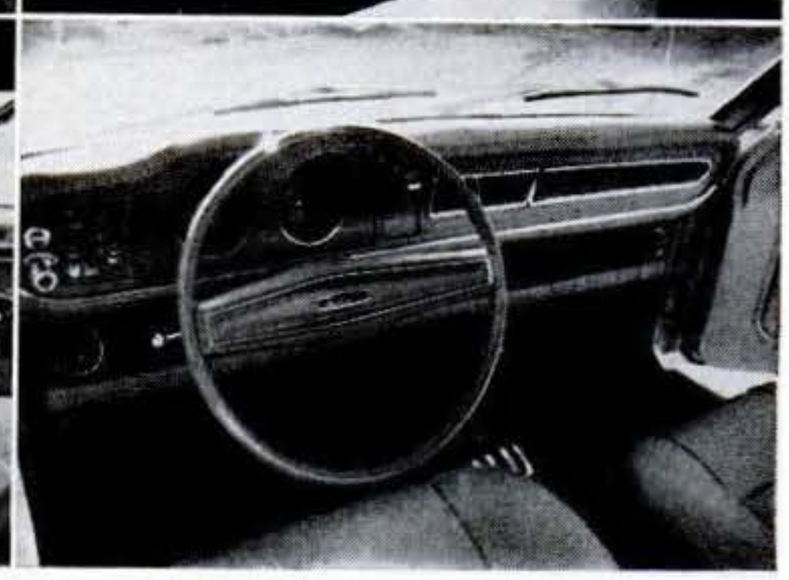

Hornet (top, left) has glove box and storage shelf, hood release well separated from brake release. **Omega** (lower left) has soft-plastic wheel, but meager glove box, limited instrumentation. **Dart** (top, right) has best instrumentation but umbrella-handle parking brake. **Comet** (lower right) lacks glove box, instrumentation is ultra-simple.

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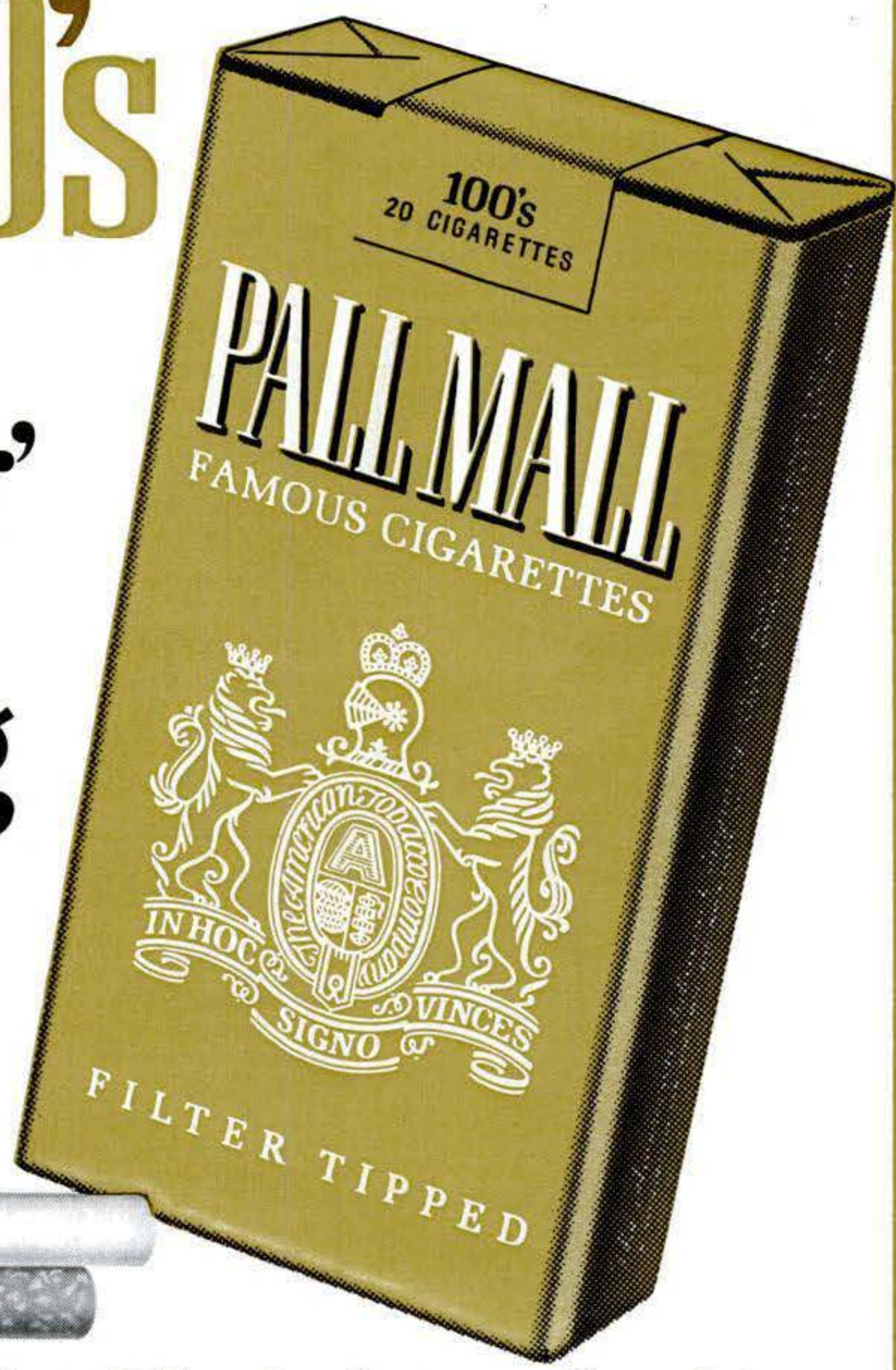
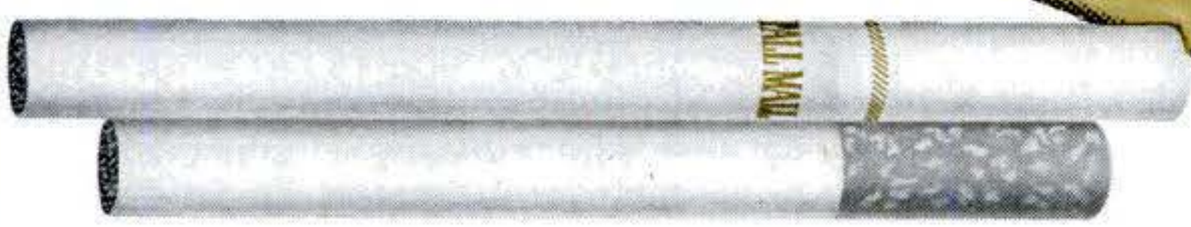
Latest U.S. Government figures show

PALL MALL GOLD 100's



lower in 'tar' than the best-selling filter king!



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20 mg. "tar" 1.4 mg. nicotine av. per cigarette, FTC Report AUGUST '72.

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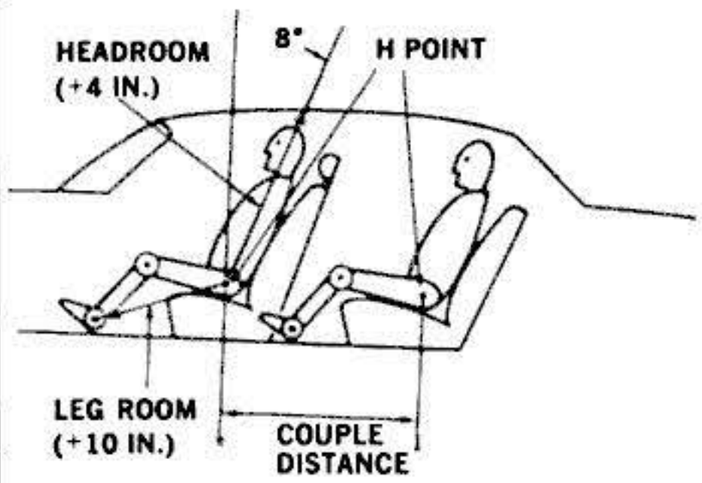
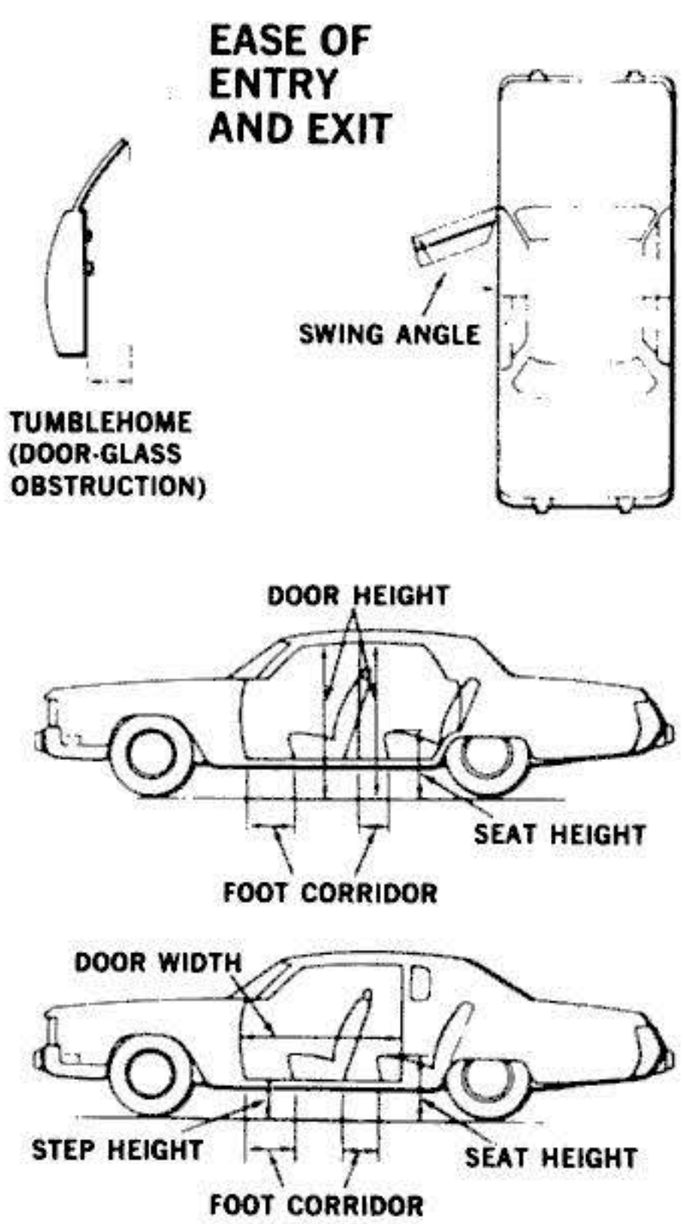
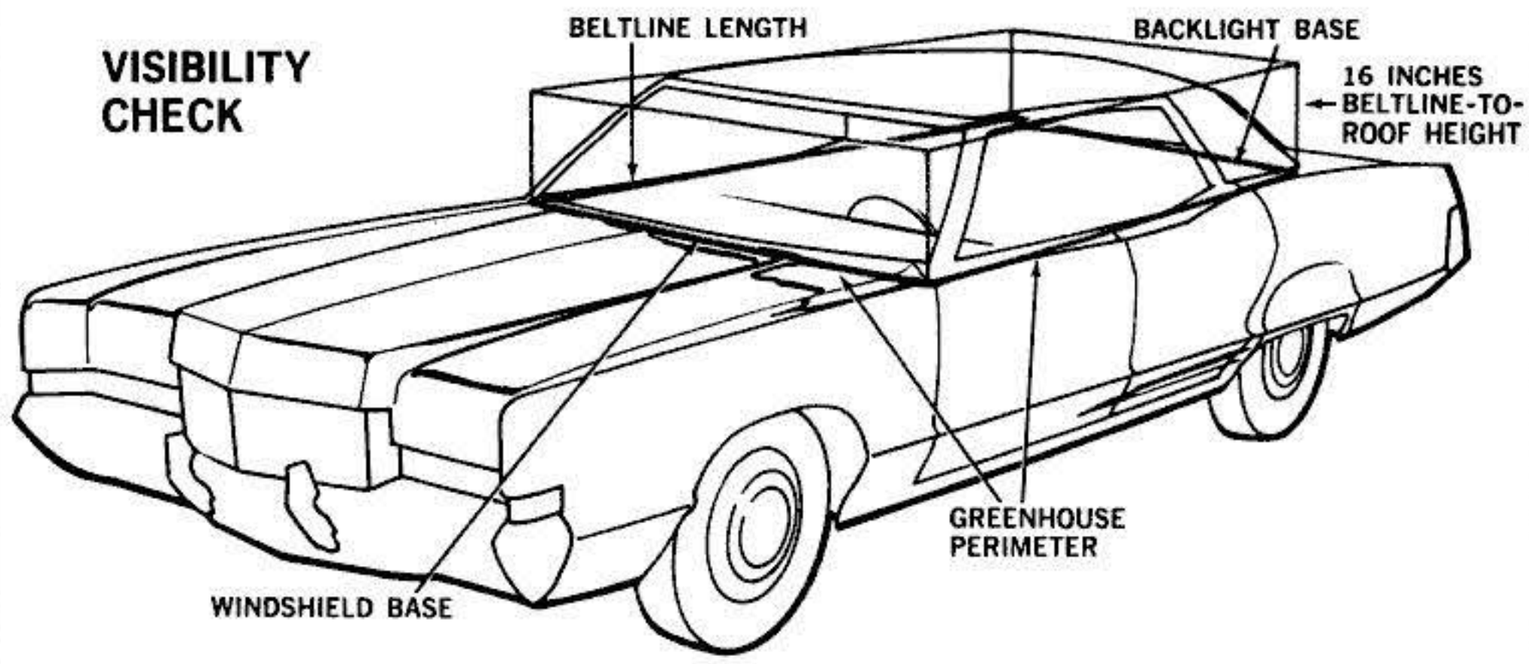


ROOMINESS

Rating for roominess is based on SAE standards for head-, leg-, and hip-room dimensions, plus H-point couple distance—an indication of rear-seat kneeroom. Hip-room is not necessarily the same as seat width, since armrests intrude on interior space in many cars. Ratings are set so that only long-wheelbase luxury cars get 5 points. Most full-size cars and intermediates rate 4 points. Compacts usually rate 3 points, and economy cars and low-priced imports 1 or 2 points. Sports cars rate 1 or zero.



Ratings for ease of entry and exit are based on six positive, three negative factors. On the plus side: front and rear foot corridors, door height and width, seat height, and maximum swing angle. The negative side: tumblehome, door-sill obstruction, and step height. Our formula gives added emphasis to foot corridors, sill obstruction, and tumblehome as factors deemed more critical. Adding rear-door dimensions into the formula fairly penalizes two-door cars.



Visibility rating has two parts: Ratio of glass area to surface of 16-inch-high walls built on greenhouse perimeter, and distance from driver's eye to object on road (over hood). Our formula penalizes cars with big sail panels (C posts), high beltlines, fast roof lines, long and high hoods, low seats—obstacles to a clear view in all directions. Most of these cars get low ratings for these "sins." Of this group, Omega is clearly superior in this area.

standard. Seat-back releases are mounted in the center of the front-seat backs—easy to find, but stubborn in action, needing real concentration and much effort. The Hornet has a satisfactory underhood layout. The distributor sits in front, and the oil filter is easily accessible from below. The plugs are somewhat crowded by the spring towers on both sides, but you can change them in 10 minutes.

Dodge Dart Sport. It replaced the Demon and plays the role of junior partner to the Swinger. It's very sound mechanically, and offers good performance with acceptable fuel economy. We believe its poor showing in the handling test was due mainly to undersized tires and a strong forward bias in weight distribution. Pump catch caused its low rating for maneuverability. As an option, you can order E70-14 tires on 5.5 JJ rims.

For us, this car's worst feature is the up-front seating arrangement. Bucket seats are set low down, with upright backrests, forcing the driver into an upright position, uncomfortably close to the steering wheel. (The seat runners can be moved back to alleviate this situation.) The instrument panel has a high hood, too, adding to the forward visibility problem. Both front-seat belt retractors jammed on our first day of testing. The belt's soft, pliable webbing folds inside the sheath and jams the mechanism. Releasing one simple catch folds the rear seat forward and it's easy to lower and return to upright position. Rear window fogs up (we recommend the optional wire-type defroster).

Dodge gets top marks for its underhood area. Electronic ignition is standard. That eliminates distributor maintenance, gives 18,000-mile plug-change interval. Plug removal is easy, except for the two plugs nearest the power-brake vacuum booster.

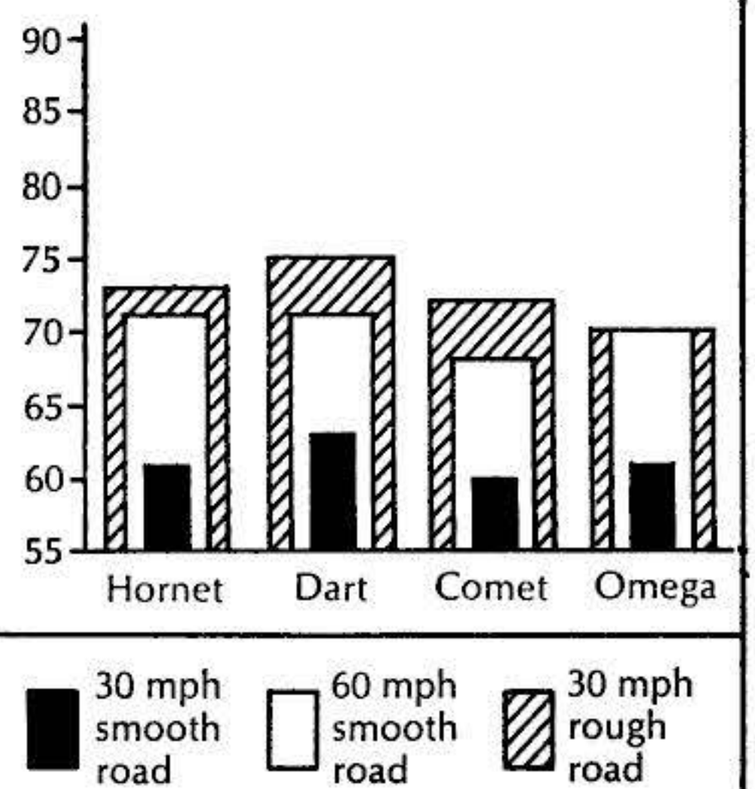
Mercury Comet Custom. Here's a T-bird in a Maverick shell. Better, because the contoured reclining seats offer sideways support as well. Radial tires are mated to special suspension tuning and an extra-quality sound package. Door panel design has a European flavor with grab-rail-type handles extending from the armrests.

Instrumentation is sparse, and though the main controls are well positioned, the Comet has a pull-type umbrella-handle parking brake down on the left side of the steering column. (Valiant has a similar handle; Hornet and Omega, pedals.) A glove box is lacking, and the dash-panel shelf is practically useless because it extends

Continued

NOISE-LEVEL TESTS

We measure interior noise in decibels under three sets of conditions, on three different scales. For quick reading of the results, we give you only the A-weighted scale, which is most like human hearing in overall sound pickup. A decibel difference of one or two points is perceptible to a driver; five points make enormous difference.



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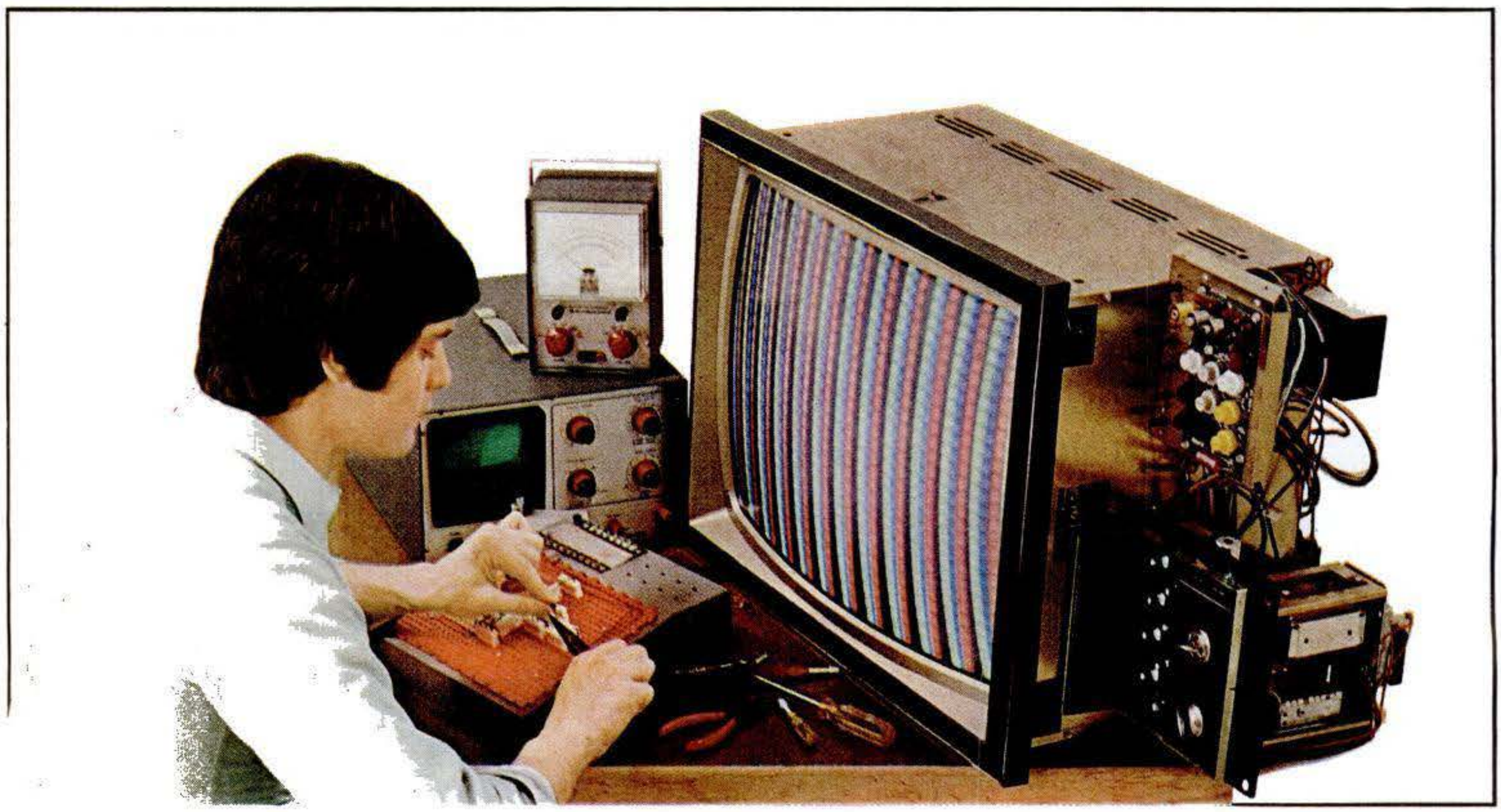

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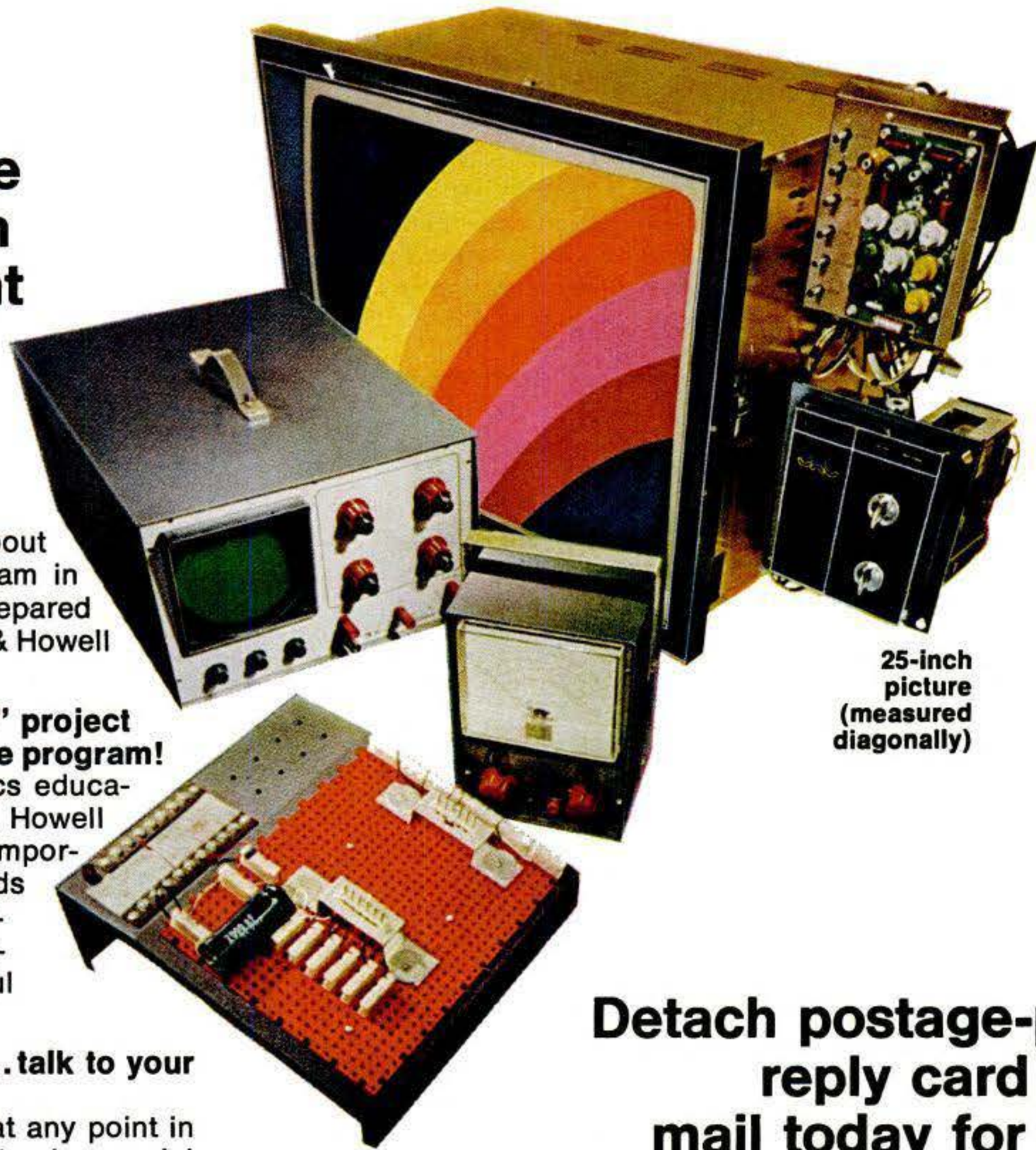

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only two-three inches from the panel.

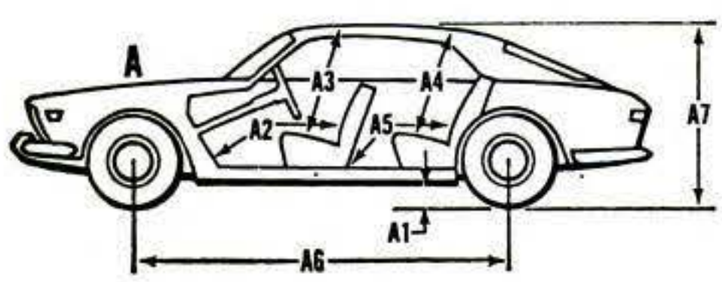
Underhood accessibility is a headache. The V8 is wedged in between spring towers. On the left, plugs can be changed fairly easily, but on the right, the air-cleaner snorkel (its front end attached to flexible pipe from the fresh-air intake) covers access to front plugs, and the bracing strut, from spring tower to cowl, covers the back ones. The distributor is up in front.

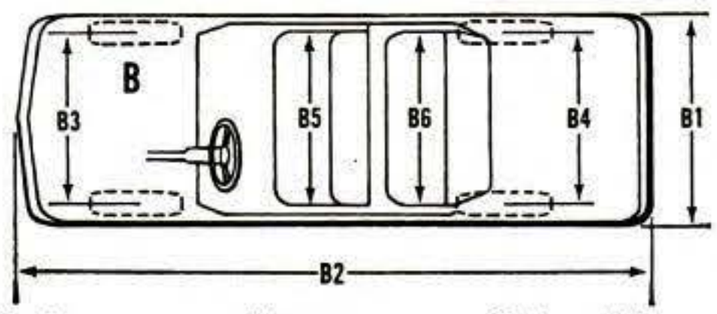
Oldsmobile Omega. This is a very civilized version of the Fisher X body (shared with Chevy Nova and Pontiac Ventura). Its hatchback is well thought out. Rear seat folds forward easily on release of one catch to form a long, wide, flat floor. But there's no security panel between luggage platform and passenger area.

Rear side windows roll down almost all the way—a much better arrangement, we think, than the flipper windows in the other compact coupes. The rear window gets fogged up and an electric defroster should be standard on the hatchback body.

The driving position is pleasantly high, and the forward view is very good. That, plus generous glass area, gives the Omega a good visibility rating. It has a poor entry/exit rating, mainly due to the problems of getting in and out of the back.

Under the hood all would be well but for the A/C installation, which almost prevents maintenance work on the entire right side of the engine. PS





	AMC Hornet Hatchback	Dodge Dart Sport	Mercury Comet Custom	Oldsmobile Omega Hatchback
DIMENSIONS (inches)				
A1 Ground clearance	5.57	5.1	3.6	4.9
A2 Front leg room (max.)	42.05	41.5	41.1	41.7
A3 Front head room	38.1	37.5	37.4	38.0
A4 Rear head room	36.7	36.5	35.9	36.9
A5 Rear leg room (min.)	31.62	30.0	31.7	33.4
A6 Wheelbase	108.0	108.0	103.0	111.0
A7 Height	53.3	53.0	53.0	52.4
B1 Width	71.1	71.1	70.5	72.4
B2 Length	184.9	200.0	185.4	197.5
B3 Front track	56.44	59.1	56.5	59.1
B4 Rear track	57.06	55.6	56.5	58.8
B5 Front hip room	54.9	57.2	53.7	55.2
B6 Rear hip room	54.4	56.9	41.5	55.0
SPECIFICATIONS				
Engine type	OHV V8	OHV V8	OHV V8	OHV V8
Displacement (cu. in./cc)	304/4983	340/5574	302/4951	350/5738
Compression ratio	8.4:1	8.6:1	8.0:1	8.5:1
Carburetion	One 2-bbl.	One 2-bbl.	One 2-bbl.	One 4-bbl.
Net hp @ rpm	150 @ 4200	150 @ 3600	138 @ 4200	180 @ 3800
Net torque @ rpm	245 @ 2500	265 @ 2000	234 @ 2200	275 @ 2800
Transmission	Automatic	Automatic	Automatic	Automatic
Axle ratio	2.87:1	2.76:1	2.79:1	3.08:1
Tire make	Goodyear	Goodyear	General	Uniroyal
Tire type	Custom Wide Tread Radial	Polyglas Custom Power Cushion	Dual-Steel Radial	Fastrak
Tire size	DR70-14	D78-14	DR78-14	E78-14
Steering	Power	Power	Power	Power
Overall ratio	19.4-15.7:1	18.1:1	21.3:1	18.9-13.5:1
Turns (lock to lock)	3.3	3.5	3.7	3.81
Turn diameter (ft.)	36	37.35	36.6	41.2
Brake system	Manual	Power	Manual	Power
Brake type	Disk/drum	Disk/Drum	Drum/drum	Drum/drum
Disk diameter	10.91 in.	10.82 in.		
Drum diameter	10 in.	10 in.	10 in.	9.5 in.
Swept area (sq. in.)	267.04	361.6	267.2	268.8
Fuel tank (gal.)	16.5	16.0	15.0	21.0
Trunk space (cu. ft.)	9.5	15.9	9.5	14.6
Liftover height	29.8	34.3	31.2	28.7
Curb weight (lbs.)	3258	3229	3087	3626
F/R weight distribution %	60.13/39.87	61.06/38.94	56.82/43.18	52.6/47.4
Price (basic)	$2449	$2511	$2951	$2734
Price (as tested)	$3365	$3193	$3311	$3607
TEST RESULTS				
Acceleration 0-60 mph	12.1 sec.	12.15 sec.	11.1 sec.	12.65 sec.
Acceleration 0-80 mph	21.3	22.4	21.95	24.15
Acceleration 25-70 mph	13.4	13.7	12.7	14.0
Braking (cool) 60-0 mph	145.4 ft.	132 ft.	181.5 ft.	126.3 ft.
Pedal pressure	85 lbs.	40 lbs.	120 lbs.	60 lbs.
Braking (hot) 60.0 mph	171.3 ft.	165.5 ft.	159.8 ft.	189.5 ft.
Pedal pressure	160 lbs.	105 lbs.	120 lbs.	200+ lbs.
Handling test (mph)	64.7	56.3	64.7	54.5
Maneuverability (mph)	26.0	23.9	27.2	25.3
Gas mileage 45 mph (mpg)	16.453	14.052	15.339	12.290

TEST CONDITIONS: Ambient temperature ..... 49° F
Humidity 66%
Barometric pressure ..... 29.6 inches

How other cars have fared in our tests

TESTS	CHEVELLE LAGUNA	FORD GRAN TORINO	AMC MATADOR	PLYMOUTH SATELLITE	AMC AMBASSADOR	CHEVROLET CAPRICE	FORD LTD	PLYMOUTH FURY GRAN SEDAN	MERCURY MONTEGO VILLAGER	PONTIAC LE MANS SAFARI	DODGE CORONET CRESTWOOD	MERCEDES-BENZ 250
Accel. 0-60	13.15	11.8	11.5	13.1	11.1	13.2	13.15	12.05	14.25	10.8	8.35	14.05
Accel. 0-80	22.6	21.55	21.0	23.95	21.7	27.55	25.85	21.8	25.15	20.5	14.8	23.75
Accel. 25-70	14.15	12.65	12.75	14.2	12.45	16.1	15.65	13.45	15.0	12.3	8.8	15.1
Braking 60-0 (hot)	186.9	134.0	160.1	156.2	158.2	206.5	164.1	182.9	152.0	146.0	191.3	126.5
Handling (mph)	53.0	58.2	53.0	56.3	56.3	53.0	53.0	53.0	45.9	56.3	53.0	60.0
Maneuver. (mph)	25.3	23.9	23.9	22.1	25.3	24.6	25.3	23.3	22.7	25.0	25.0	28.6
MPG (45 mph)	14.5	14.7	14.3	15.2	14.1	10.9	14.2	11.7	12.1	14.0	13.8	12.8
Noise (60 mph)	69	68	70	70	68	64	64	66	66	68	69	74
Price	$3924	$4126	$3681	$3489	$4776	$5017	$5236	$4939	$4668	$4221	$4641	$7221

Turn-signal lamps are inset in grilles, inboard of headlights, on Comet (top), Dart (third from top), and Hornet (bottom). Only Omega (second from top) has turn-signal lamps at car's full width, inset in the bumper. Hornet bumper lacks overriders.

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This pickup comes with new passenger car interiors and rugged Jeep guts.

The Jeep Truck has always had a reputation for being tough. After all, it's got the most famous 4-wheel drive of them all . . . and a payload capacity, on its 8000 Gross Vehicle Weight model, of 3500 pounds. It's been known for its low center of gravity, which gives you extra stability on steep, rocky hills. And its high ground clearance, which takes you over those stubborn obstacles that would make other pickups turn back. Now the Jeep Truck will be famed for its interior, too. Seats have deep foam padding. (Bucket seats are available.) There's a new padded instrument panel. And a new padded steering wheel. Plus color-keyed mats. And air conditioning, if you want. When you're out exploring for your own campsite, you need guts—and comfort. The Jeep Truck gives you both.

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Buckle up for safety...drive your Jeep vehicle with care and keep America the Beautiful.

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Only KOOL with pure menthol has the smooth taste of extra coolness.

Come up to KOOL

Kool Milds 14 mg. "tar," 1.0 mg. nicotine av. per cigarette, by FTC method. Kool Kings 18 mg. "tar," 1.5 mg. nicotine; Kool Longs 18 mg. "tar," 1.4 mg. nicotine av. per cigarette, FTC Report Aug. 72.

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Warning: The Surgeon General Has Determined That Cigarette Smoking Is Dangerous to Your Health.

14 mg. tar, 1.0 mg. nicotine

Now, lowered tar KOOL Milds

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PS: What's News...

Keeping You Posted from Behind the Scenes

When we first read Ford's announcement that the Detroit giant had signed a multimillion-dollar agreement for a license to build a new kind of Stirling-cycle engine, several of us here thought the description of the engine had a familiar ring. Checking our files, we found what appeared to be the same engine described, and a cut-away drawing shown, in Dave Scott's June 1971 story about the Philips Stirling bus engine. Dave had stumbled onto the new engine while it was still under construction at the Philips Lab.

For this month's cover story, Auto Editor Jan Norbye went to the Philips labs in Eindhoven, The Netherlands. Norbye reports: "I met with Dr. Roelof Jan Meijer, the world's leading expert on the Stirling cycle, who has devoted a quarter century to the Stirling engine. As he revealed details of this latest engine, I was enormously impressed by his vast knowledge of thermodynamics and energy conversion in all forms. Apparently no secrets were to be kept from POPULAR SCIENCE readers. The wraps were taken off all the latest experimental hardware. Most unforgettable was watching the new double-acting, swashplate engine running on a test stand. Unbelievable! Only the visible rotation of the shaft revealed that it was running at 1500 rpm. Just a whisper. No vibration. I was particularly impressed because two days earlier I was at NSU watching two-rotor Wankels being tested. Though the Wankel is quieter and smoother than piston engines, in comparison the Stirling makes Wankels sound like thunder."

Of course, the Philips people would not discuss the details, or what Ford's plans for the engine are. For that part of the story Jim Dunne went to see Ford engineer Jack Collins. Meanwhile, Artist Ray Pioch was working on the cover painting based on information sent by Jan from Europe and guidance from Larry Loeffler of North American Philips. For the first comprehensive report on this latest starter in the Detroit sweepstakes, see page 72.

It's later than you think

Within the space of a few days, two of our editors returned from different technical conferences with the same ominous news. Both had heard speakers with impressive credentials predict gasoline rationing soon. At a meeting in Boulder, John F. O'Leary, former Chief of the Bureau of Natural Gas, former Director of the Bureau of Mines, and presently Director of Licensing, AEC, said: "There has been a tragic lapse in the U.S. in developing alternatives to our on-going energy program . . . There will be constraints on our use of energy because of radical price increases. The situation with gasoline is so bad we may have rationing within a year." Soon thereafter at an ASME meeting in New York, Gerard G. Gambs, VP of Ford, Bacon and Davis, and an energy expert with a record of more accurate energy projections than the federal agencies, predicted there *will* be gasoline rationing this summer.

Both speakers delved into other ramifications of the energy gap—gasoline shortage is only the tip of the iceberg—but impending gasoline rationing, it seems to us, will have the greatest impact on public policy. Most people won't recognize that the energy crisis affects them until they wake one morning and find restrictions on driving their cars—then all hell will break loose. Voters will demand, in ways that can't be brushed aside, that their public officials implement effective energy policies.

We have dawdled too long to avert a short-term crisis, but for the long haul there could be plenty of energy to meet our needs if we get cracking. We must learn to use energy more efficiently and stop our national impulse to place all our bets on one horse in the race to meet energy needs. We lean too heavily on petroleum for the present, on nuclear power for the future. We can no longer afford to neglect alternative energy sources such as solar [PS, Dec. '72], geothermal [PS, Aug. '72], fuel cells [PS, Aug. '71], MHD [PS, June '69], coal gasification [PS, July '71] and even minor sources limited to certain geographical locations such as windpower [PS, Nov. '72] and tidal power [PS, June '65].

Concern for the environment has inadvertently contributed to the crisis. Hastily conceived and inadequately researched laws and regulations aimed at curbing pollution are in many instances making matters worse, and in others exacting an energy cost far out of proportion to insignificant gains in reducing pollution. Everyone is against pollution, but it's time to look behind emotional slogans, banner waving, and invective to find the facts that will let us strike a reasonable balance between cost and effectiveness.

Where does all the energy go?

A study for the Office of Science and Technology made by the Stanford Research Institute shows how we have been consuming energy: approximately 41 percent to make things for ourselves (industry), 25 percent to move our things and ourselves (transportation), 19 percent for comfort and convenience at home (residential), 15 percent for our comfort and convenience in stores, offices, shops (commercial). Where does it come from?

Natural gas is favored, with 50.1 percent of home-use requirements and 43.3 percent of industrial requirements met with gas. Commercial and transportation users lean toward petroleum products: 49.2 percent of commercial needs and 95.8 percent of transportation needs are met with gasoline or fuel oil. Electricity supplies only 15.1 percent of home needs, 15.7 percent of commercial requirements, 9.6 percent of industrial consumption, and only 0.1 percent of that used for transportation. Each fuel's contribution to electric-power generation were: coal, 57.3; gas, 26.1; petroleum, 9.5; hydro and nuclear, 7.1 percent.

The growth patterns of fuels used underline our national tendency to put all our eggs in one basket. Not only have we limited ourselves to three main energy sources, but our most abundant present energy resource—coal—is significant only in industry, and even there it supplies only one-fourth of the needs.

Hubert P. Luckett

Editor-in-Chief

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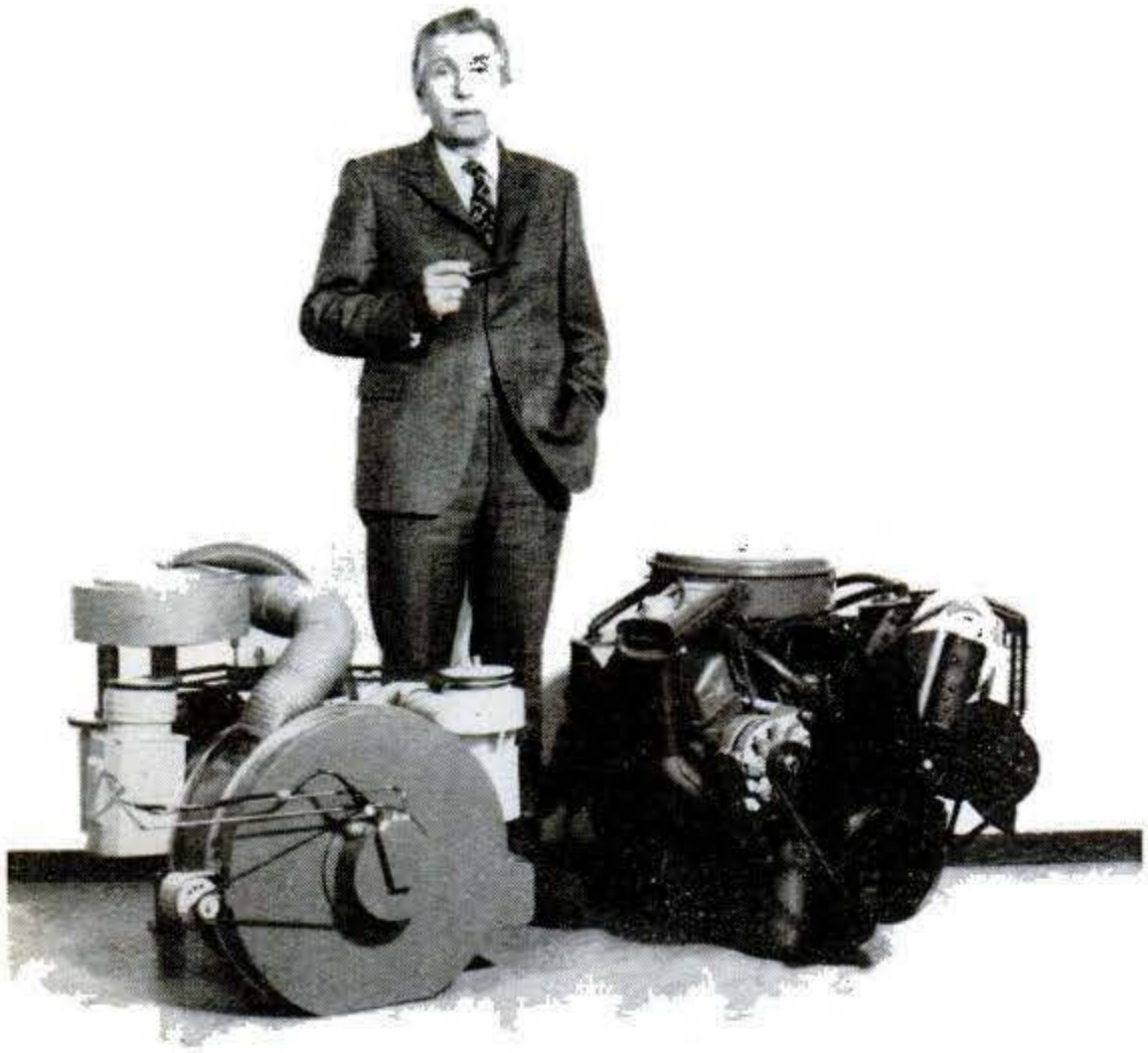
FORD'S GAMBLE—

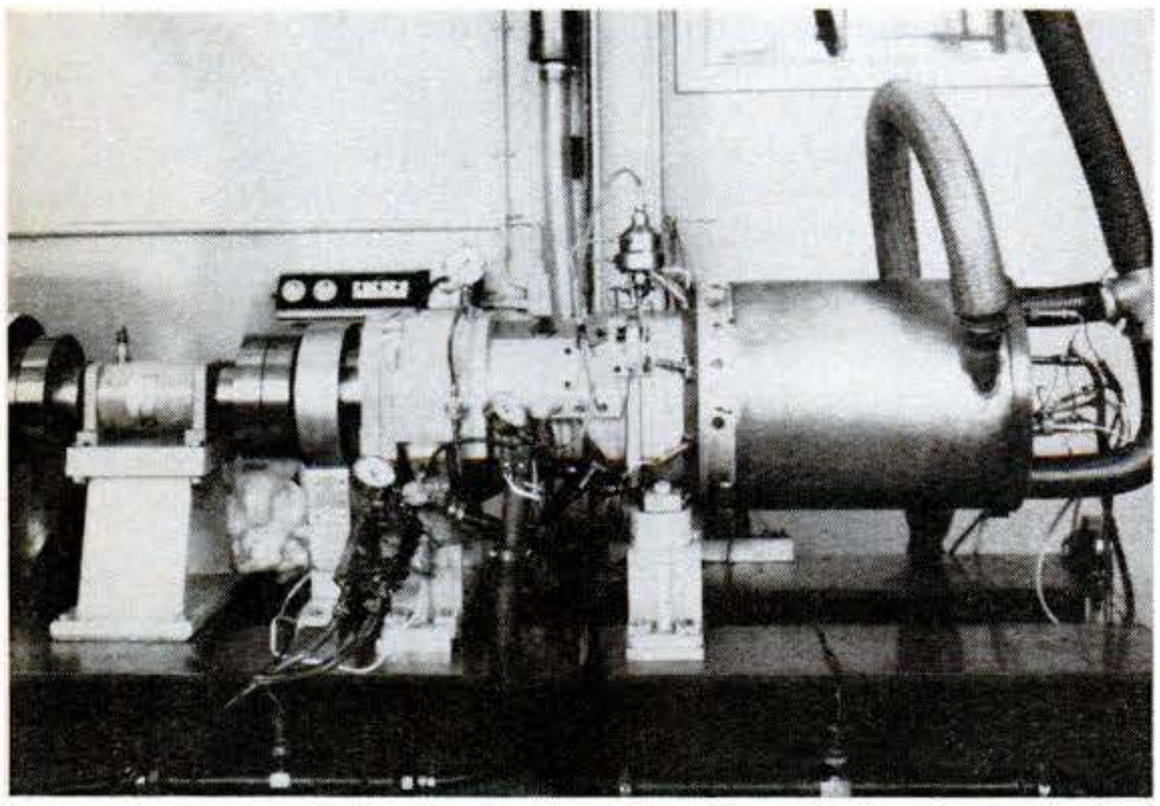
Stirling-Cycle Engine Promises Low Emissions Without Add-Ons

Your car of the future could have almost no air and noise pollution, with vibrationless running and capability for multifuel use

By **JAN P. NORBYE** / *PS Automotive Editor*
and **JIM DUNNE** / *PS Detroit Editor*



Stirling engine mockup (left) can be installed anywhere there is room for a '73-model Ford V8 (right). Behind the engines stands Dr. Roelof Jan Meijer, head of the Stirling engine section of the Philips Research Laboratories in Holland, during a visit to Ford. He says the new double-acting four-cylinder Stirling engine is competitive with the V8 in both size and weight for a given power output. The Stirling offers superior fuel economy—it's an external-combustion engine that can burn various fuels, liquid or gaseous.



Philips prototype Stirling engine of double-acting type with swashplate drive is rated at 60 hp. The engine itself is at center, with a huge (old) burner unit on the right and the dynamometer coupling on the left. This engine was undergoing endurance testing at time of our visit to Philips, and we saw it run in uncanny silence and totally without vibration at 1500 rpm. Cylinders are horizontal (parallel with output shaft). Burner size has been considerably reduced in later designs (see drawings, next page).

Stirling-powered cars?

When the Ford Motor Company signs an agreement for the rights to build a Stirling engine, you must suspect that its intended use is in automobiles. And last July, Ford did come to such an agreement with Philips Gloeilampenfabriek N.V. of Eindhoven, in the Netherlands, where the Stirling engine has been under continuous development since 1938. Last month we learned that Ford also entered a joint technical program with United Stirling AB in Sweden, where two Pinto cars will be equipped with Stirling engines.

The automobile Stirling engine is still strictly experimental, but it has a lot going for it. POPULAR SCIENCE has reported on its progress every step of the way. Harry Walton reported on its use in space satellites [PS, July '65]. Jim Dunne drove GM's Stirling-electric Opel [PS, Dec. '68], and David Scott reported on Philip's Stirling-driven DAF bus [PS, June '71].

Is this the same Stirling engine that GM gave up on in 1970? Basically, yes. Then why does Ford want to pick it up now? Two reasons: First, GM wasn't developing an *automotive* Stirling engine. It was a space-engine program, instituted at Allison Division in the wake of the Sputnik shock of October 1957. The electric Opel with the single-cylinder Stirling engine was a basic feasibility study, no more. Later, fuel-cell technology solved NASA's problems, and GM then dropped the Stirling. Second, Philips has made spectacular progress in Stirling engine development in the last two to three years, making it far more attractive as an automobile power plant.

To find out why Ford wanted the Stirling, and what Ford hopes to achieve with it, we went to the fountainhead, to Philips in Eindhoven, as well as to Ford in Dearborn. (We also received valuable help from the U.S. Philips Corp. in New York.)

The man who has brought the Stirling engine to the point where it is today is a Dutch engineer, Dr. Roelof Jan Meijer (pronounced Meyer), who came to Philips 25 years ago, and has been working on Stirling engines ever since. As a result of his research and development work, Philips now has a unique bank of knowledge concerning this engine, its operational cycle, and its applications. Dr. Meijer gave us three reasons why he thinks all large auto makers should be interested in the Stirling engine:

1) The Stirling is nonpolluting (meets the '76 emission standards).

2) It is quiet (noise-pollution standards are coming).

3) It has multifuel capability and excellent fuel economy, which promises better conservation of our natural resources.

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Let's examine all of these important claims in detail:

Clean air. Philips designed a horizontal four-cylinder double-acting engine with swashplate drive, rated at 128 kilowatt output (172 hp), for installation in a modified 1972 Ford Torino. Test simulations show, on the basis of calculated fuel flow, it would easily pass the '76 federal standards for HC and CO emissions with diesel fuels. With exhaust-gas recirculation (EGR), it would also hold NO_x emissions to 0.16-0.20, well below the 0.40 g/mile limit.

Why is the Stirling engine so clean? It's a closed-system external-combustion engine with constant burning and large amounts of excess air available for the combustion process. That's enough to guarantee practical freedom from HC and CO in the exhaust. With partial EGR, combustion temperature can be held down to 1240-1400 degrees F, where NO_x emissions are practically nonexistent.

Fuel economy. Ford supplied fuel consumption figures for a 1970-model 351-cubic-inch V8 derated 15 percent to represent '76 performance level. This was used as a basis of comparison for the simulated tests with the Stirling Torino. Here are the results.

	'76 Ford V8	Stirling-Torino
Consumer average	10.7 mpg	14.2 mpg
Suburban driving	13.3 mpg	17.5 mpg
City traffic	8.2 mpg	11.0 mpg
Superhighway	13.0 mpg	18.2 mpg

Conservation of resources goes beyond fuels, of course, and into the amount of material needed to build the engine. The second-generation Stirling is comparable to the passenger-car V8 in size and weight; the first generation Stirling was about as heavy and bulky as a diesel of similar output.

Noise? The Stirling's claim to silent running is not contested. Its freedom from noise is a startling discovery for doubters who watch the engine on the dynamometer for the first time. Decibel readings are 20 to 40 dbA below automotive diesel engines. That's almost as quiet as electric cars!

Other properties that count heavily in favor of the Stirling engine are:

- Almost total lack of vibration (torque vibrations occur as the 4th harmonic).
- Instant throttle response and wide speed range.
- Compatibility with existing transmission systems.
- High part-load efficiency.
- Strong brake effect on closed throttle.
- No oil consumption; very infrequent oil changes.
- Absence of cold-starting problems.
- Extremely long service life (test units have gone 10,000 hours *under full load* without stopping, and without maintenance adjustment).

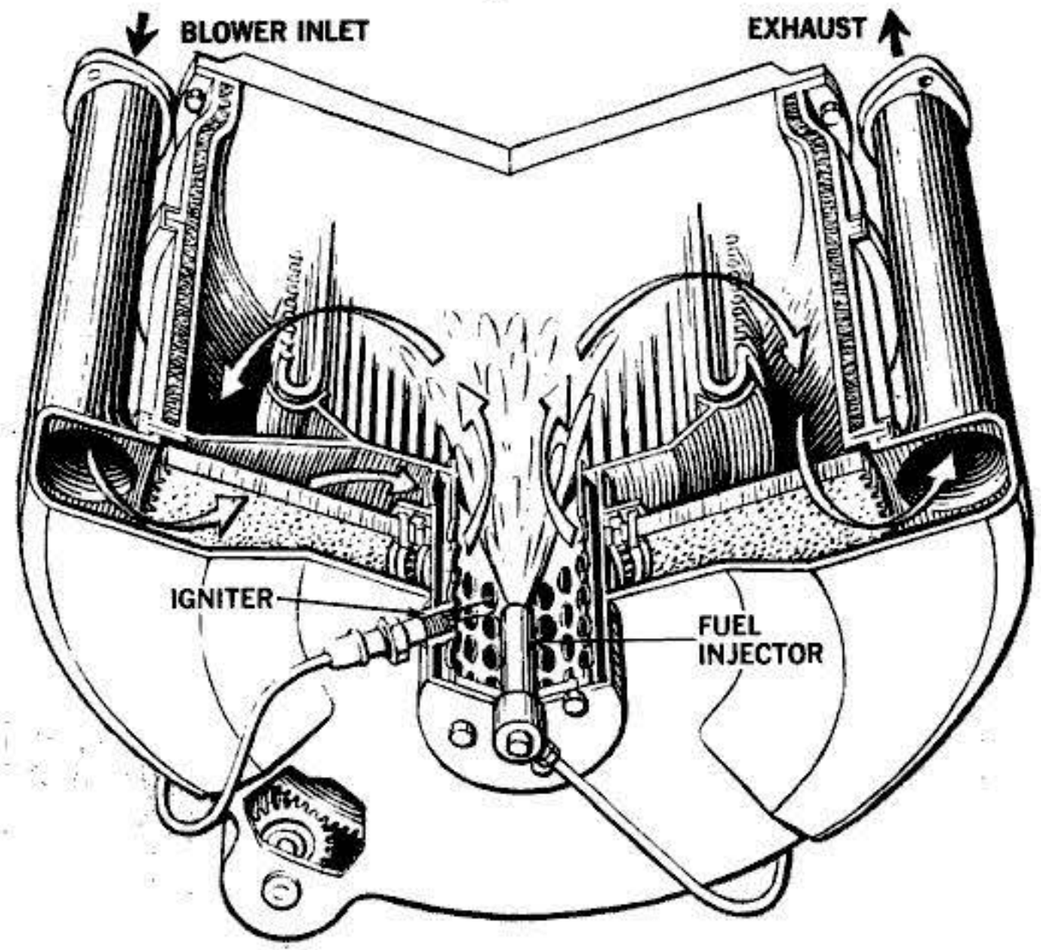
Lest this begin to sound euphoric, let us rush to say that there are still some problems associated with the Stirling engine. Dr. Meijer is the first to admit that "the hardware is enormously expensive." Of course, he is not speaking in absolute terms.

Remember that the Philips Research Laboratories are completely divorced from production matters. Cost studies have not been made. The sole objectives have been to make the engine work and to raise its power-to-weight ratio. The parent company, Philips Gloeilampenfabriek N.V. is a Dutch-based multinational organization and a world leader in the production of electric and electronic equipment, but by no means an engine manufacturer. Ford, on the other hand, is no doubt deep in cost studies right now.

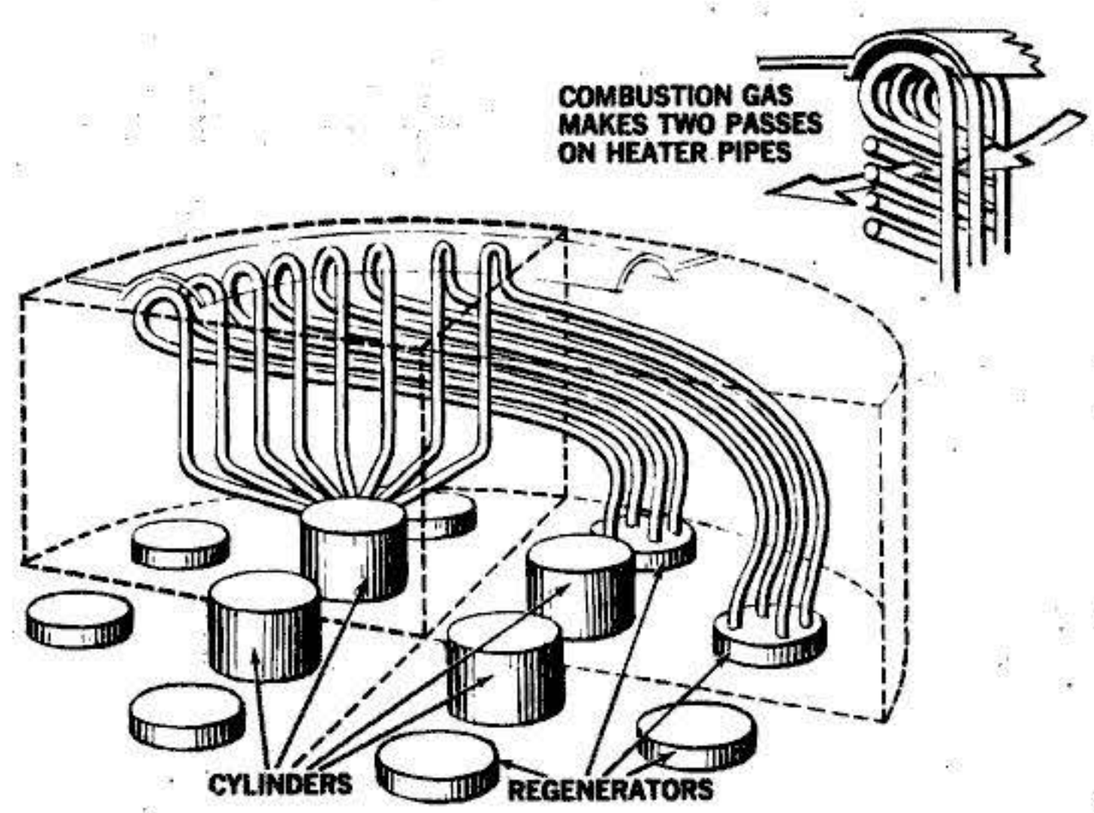
As for technical problems, Philips has identified and corrected most of them. With the switch to the double-

Continued

Combustion and regeneration

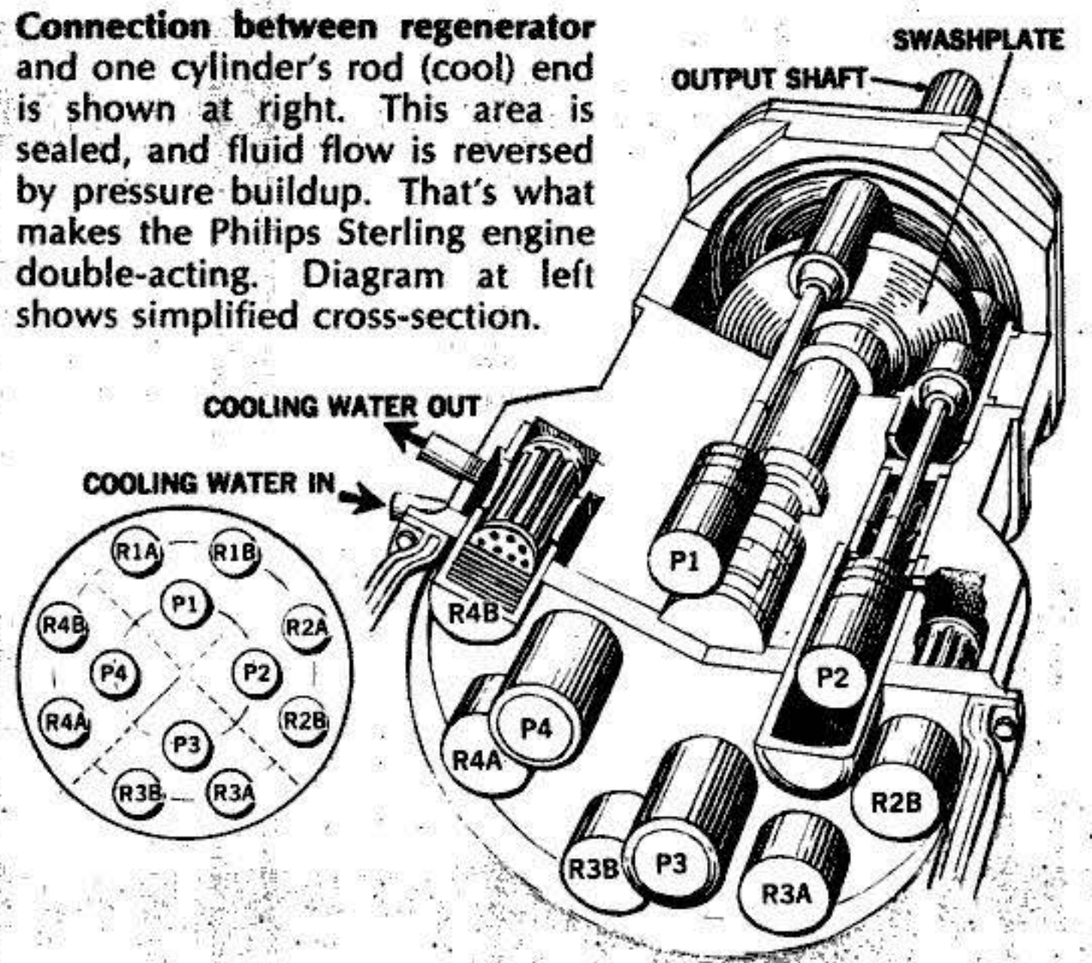


Air enters from blower (top left) and is piped to front face of preheater core. Arrows show gas flow path through combustion process, to exhaust (top right). Seals prevent mixing of fresh air and exhaust gas past preheater bearing.



Each cylinder is connected to two regenerators adjacent to a neighbor cylinder. Hydrogen working fluid flows through eight cooling pipes from hot end of a cylinder to two regenerators before going to cool end of next cylinder.

Connection between regenerator and one cylinder's rod (cool) end is shown at right. This area is sealed, and fluid flow is reversed by pressure buildup. That's what makes the Philips Sterling engine double-acting. Diagram at left shows simplified cross-section.



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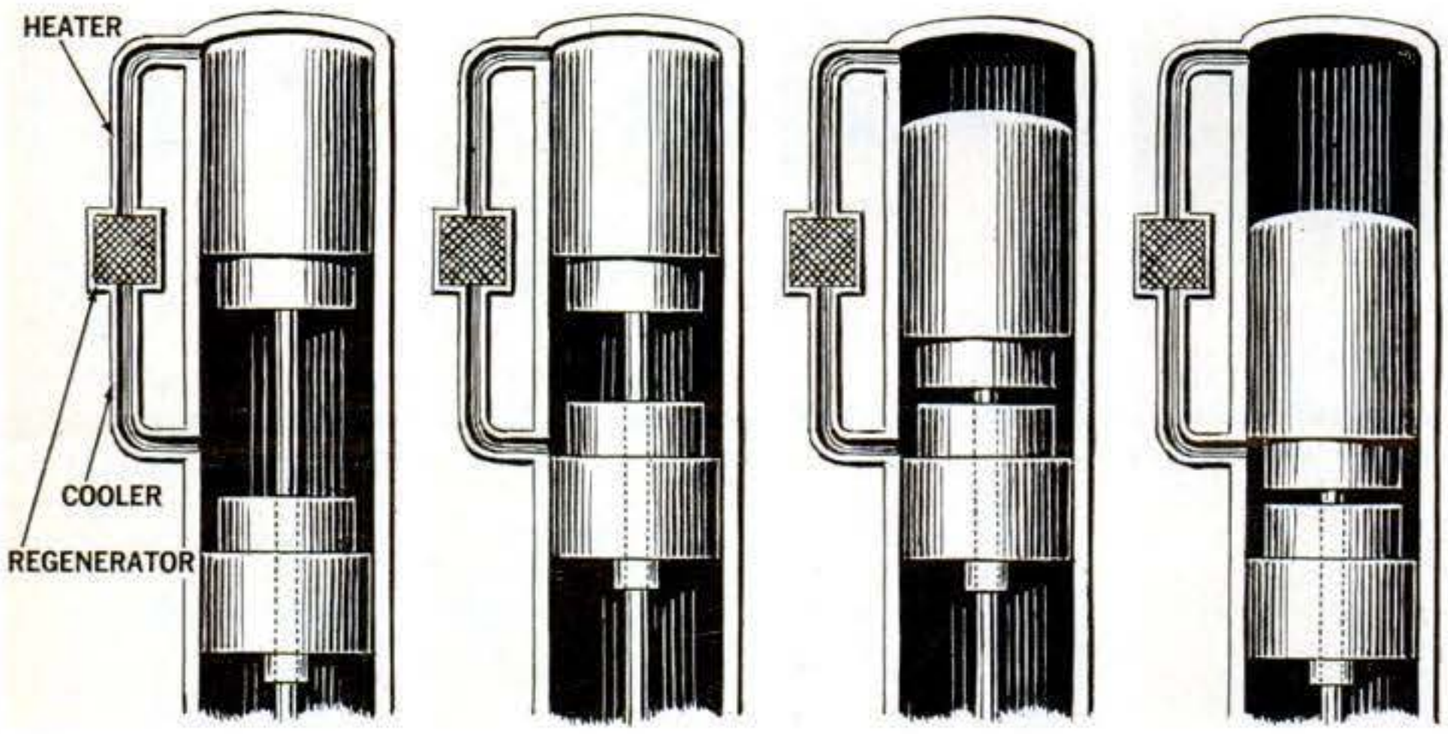
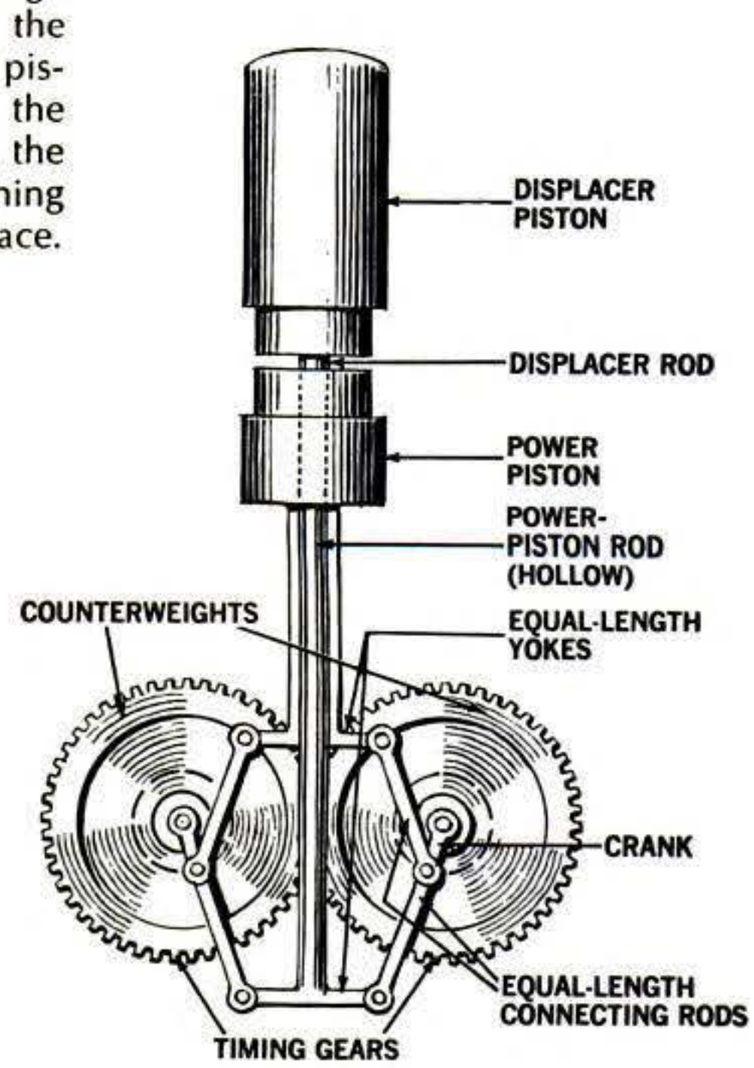
The single-acting Stirling engine—and how it works:

Power piston and displacer piston have coaxial rods connected to different points on the rhomic drive. Rhomic drive is what keeps pistons in proper relation to each other. Each cylinder has its own burner. "Crankcase" is pressurized. At left, all gas is in cool space between pistons. Then power piston moves up, compressing cool gas at constant temperature. Next, displacer comes down, forcing the gas up through regenerator to the hot end, where the heated gas expands, driving the power piston, and also derives some push from the expanding gas. After the power stroke, the displacer returns to top position, returning hot gases via regenerator to cool space.





acting engine, the power-to-weight ratio jumped into the major league. Behind the switch, a combination of basic changes:

1) From 4 cylinder-in-line to in-square formation.
2) From single-acting pistons with pressurized crankcase to double-acting ones with atmospheric crankcase.
3) From rhombic drive to swashplate.
4) From one heater unit per cylinder to a combined burner for all four cylinders.
5) Adoption of working fluid conduits from the hot space of one cylinder to the cool space of the next cylinder.
6) Elimination of the displacer pistons in this engine.

Sealing—a big problem. The working fluid must be hermetically sealed. When you're dealing with helium or hydrogen under 200-atmospheres pressure, you can understand that seals might be a weak point. The most critical point was sealing the piston rod against the housing.

The solution was a rolling diaphragm (roll sock) with its inner edge anchored in the housing. All motion is restricted to the diaphragm itself, which is made of reinforced polyurethane rubber. It forms a seal between the high-pressure working fluid above and the crankcase below. Its primary task is to prevent the escape of working fluid; its secondary task, to prevent penetration of crankcase oil into the working fluid.

Heat-exchanger efficiency was very low in the early Stirling engines. Now Dr. Meijer claims 99 percent efficiency for the regenerators in the double-acting engine, which means you can't expect any further improvement in that area.

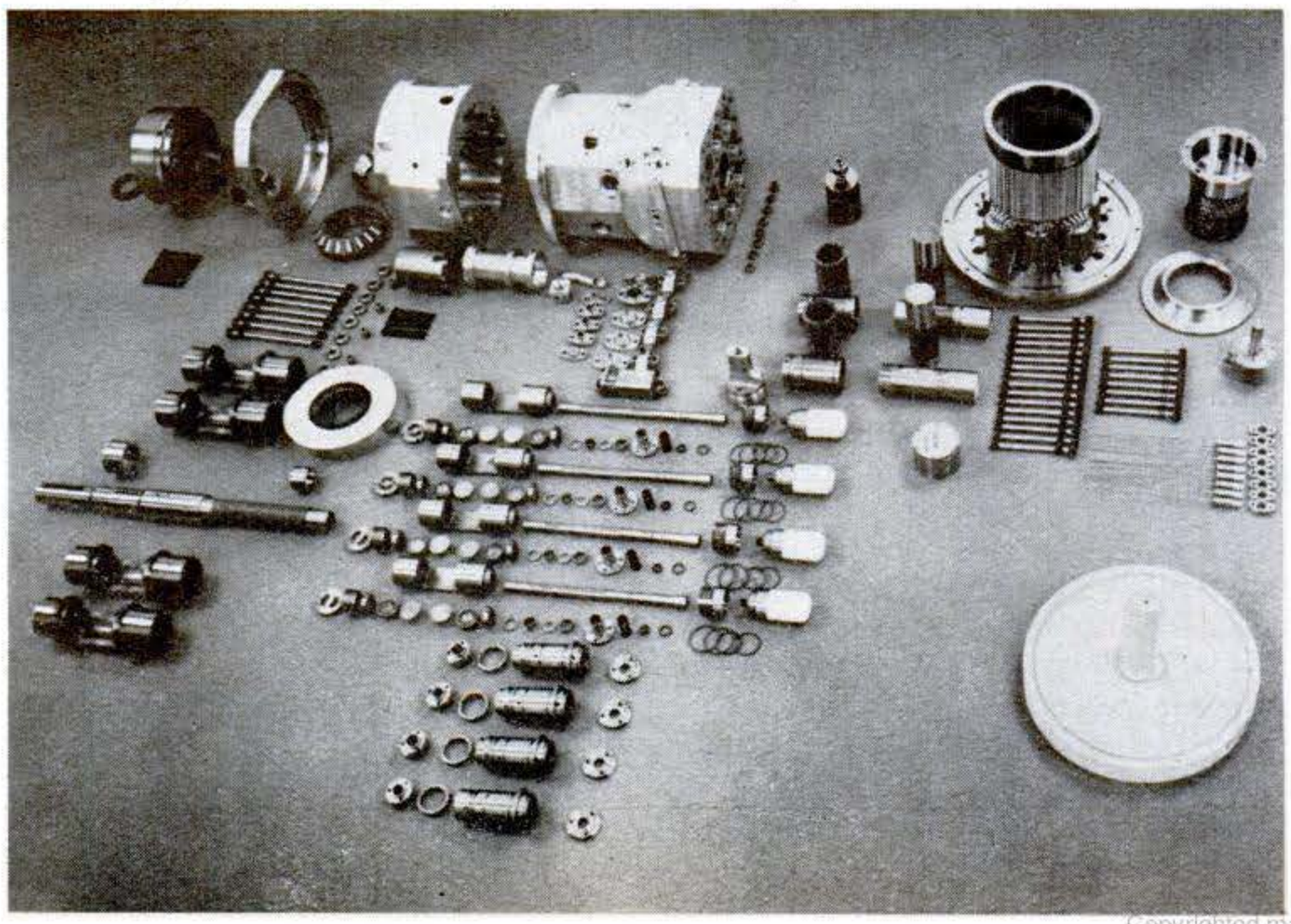
Heat discharge to a car radiator would still be a problem if Philips had not developed a new type of radiator. The Stirling puts twice the cooling load of a V8 of similar power into the cooling system.

Philips made scientific studies of heat-transfer and heat-flow resistance in preparation for an analysis of radiator heat dissipation. Then Philips designed its own accordion-type radiator, with narrow slits at the end of each V. It occupies the same space as conventional radiators but uses only 24 percent of the raw material weight. It has a heat-rejection rate 2½ times better, and fan-drive power requirement 2½ times less.

Of course, new problems will presumably appear dur-

The parts of a double-acting Stirling engine

Despite simplicity of working cycle, the Stirling needs impressive number of parts. But moving parts are few: pistons, connecting rods, rod guide inserts, swashplate, output shaft. Preheater core rotates also, driven by chain from an electric motor.



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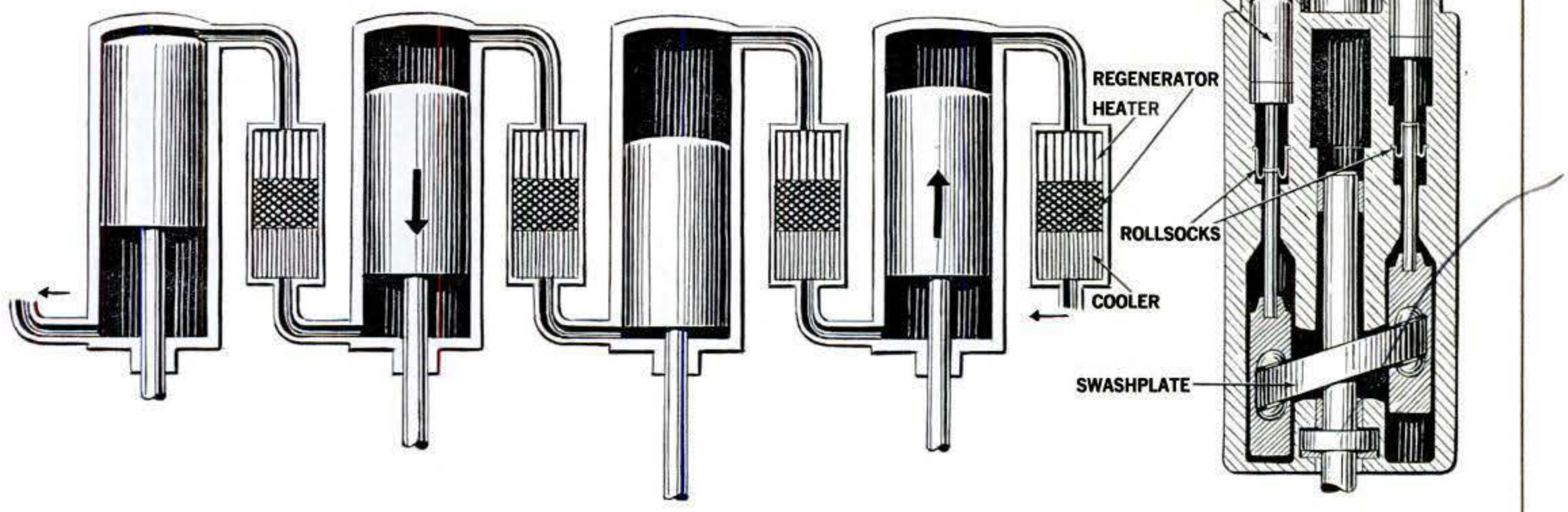
The new double-acting Stirling engine—and how it works:

Single burner serves four cylinders grouped in a square. Hot end of one cylinder connects to cool end of neighbor via a regenerator that collects heat from hot gases on their way down, restores heat to cool gases on their way up. There's no displacer piston, and cool end is sealed off from crankcase, no longer pressurized. All four piston rods connect to a swashplate. Rods run in guides, do not bend or swing. They exert pressure against the angled plate, transmitting a wedging action causing swashplate to revolve and turn the output shaft. Four pistons, phased 90 degrees apart, deliver one power impulse for every quarter turn of the output shaft.



ing testing of passenger-car-type Stirlings. Presumably, most will be solved. If all problems are solved, Ford has firm and specific plans for the engine:

1973-75—Cooperate with Philips in building a prototype 175-horsepower engine to be installed in an intermediate-size car (Ford Torino) for testing.

1975-76—Build a number of engines in Dearborn to work out final manufacturing problems, and expand the testing program to additional prototype cars.

1977-1980—Order the machine tools and construct the factory needed to build the Stirling in high production numbers.

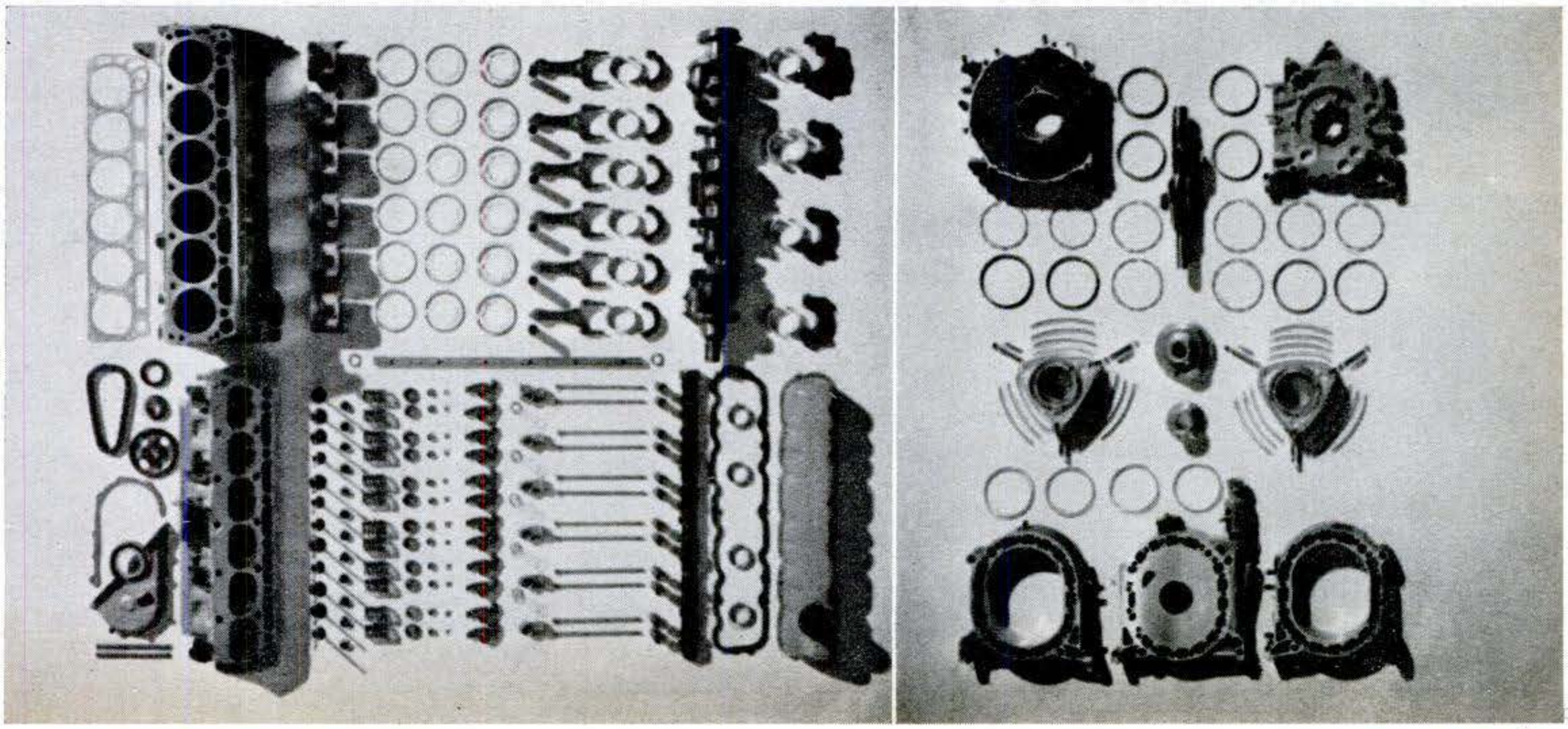
Ford's prime concern right now is to get a full-size Stirling into the 50,000-mile-emission test cycle, and see if it can stay clean for the full period required by the U.S. government. Jack D. Collins, chief of passenger-car research for Ford, says it will take considerable in-car testing to prove that the engine does meet the ultra-strict '76 standards.

Ford has about 35 engineers working on the Stirling project right now. Two of the biggest problems are designing a system for fabricating the cooling tubes and building a radiator big enough to take care of the cooling

[Continued on page 154]

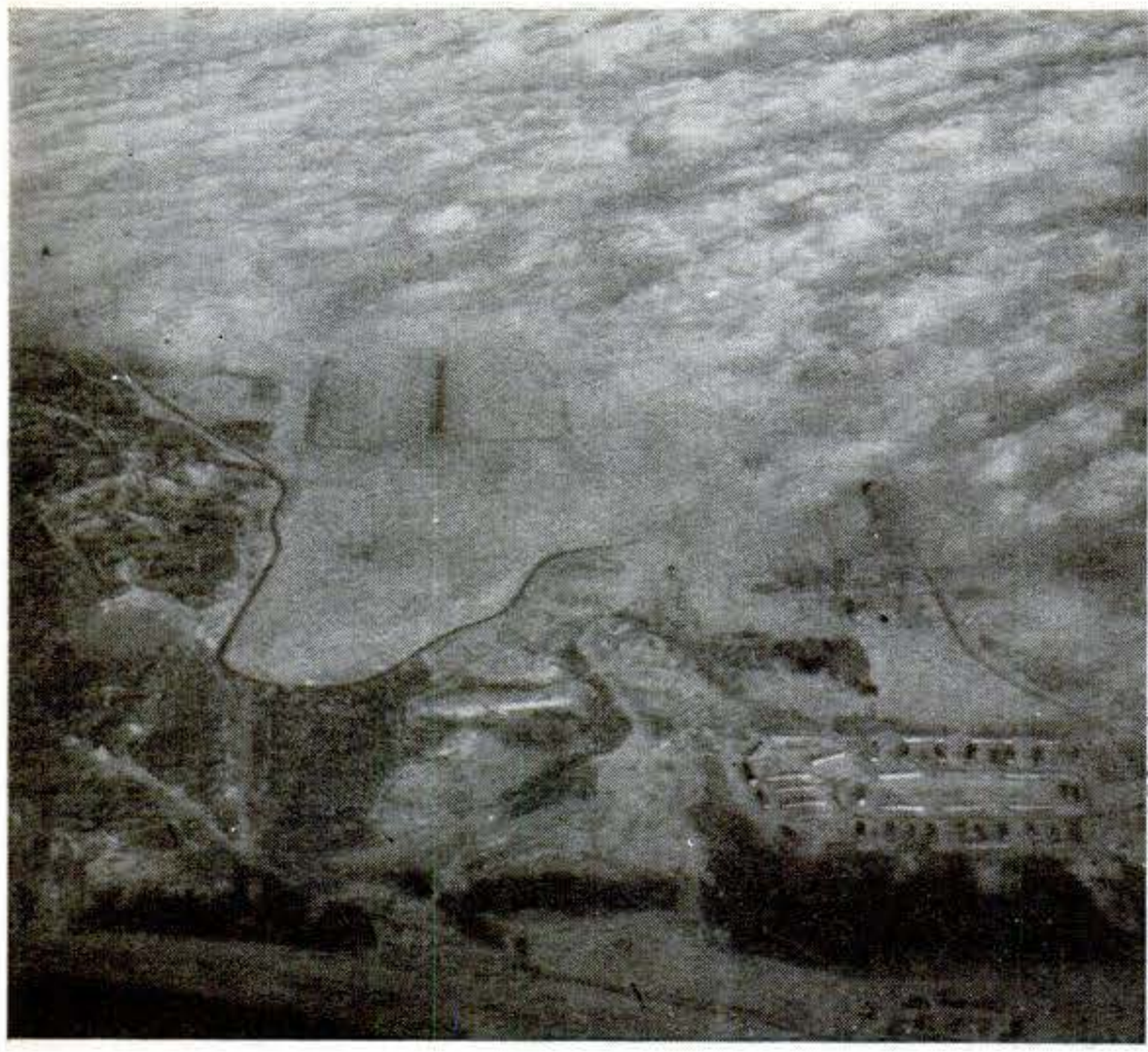
For comparison: An in-line six and a twin-rotor Wankel

Conventional internal-combustion engine is most complex and has disturbingly high number of small and high-precision parts. Moving-parts count is also very high. Valves and valve-gear parts, special offenders, are eliminated in Wankel (right). Moving parts in rotory engine are extremely few, but many small parts perform critical tasks and must be made with high precision.

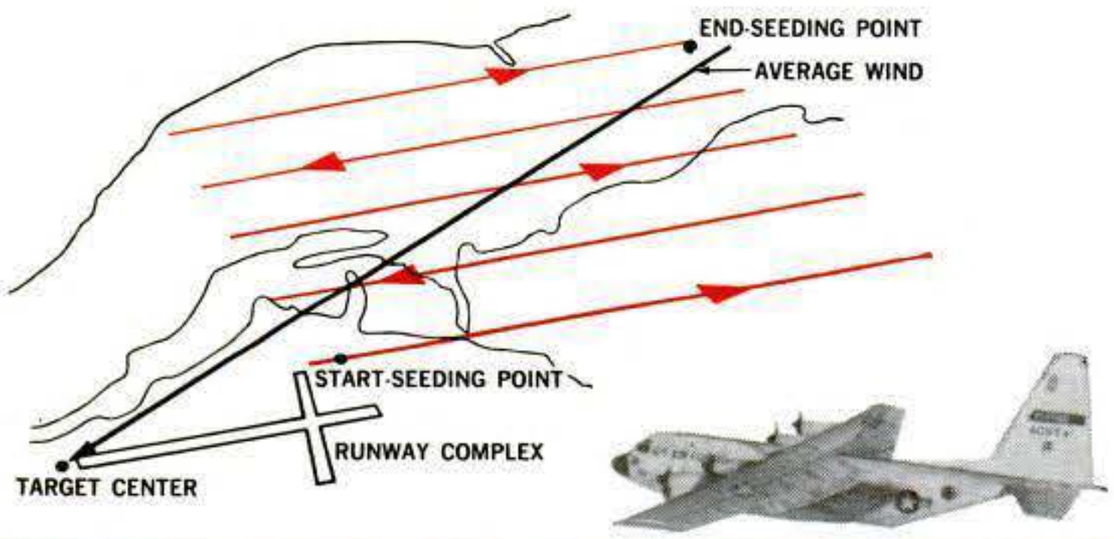


New techniques can clear airports for safer landings, and some day may make highway driving easier

How Science Wages the Fight



Before-and-after shots show results of airborne seeding with crushed dry ice to clear cold fog at Elmendorf AFB, Alaska. The Air Force now uses newer on-ground liquid-propane dispensers.



Airmen pulverize blocks of dry ice for fog seeding inside cargo hold of C-130. Drawing above shows pattern flown by planes upwind of airstrip so that the cleared area drifts over it.

By **BEN KOCIVAR** / *PS Consulting Editor, Flying*

If you encounter fog while traveling, it may be bad news. Despite today's sophisticated landing and radar systems, fog can still shut down airports, delaying or diverting your plane flight, costing the airlines millions of dollars each year. And travel along a crowded, fog-bound highway can be a deadly, nerve-wracking experience. A persistent fog can even trap pollutants.

We've had a grab bag of fog-clearing techniques for years. But the most common method, airborne seeding, is costly, and until recently worked with only one type of fog. Other fog-dispersal methods may create undesirable side effects.

Now, after extensive research by government and industry, important new progress in fog cutting has been achieved. The new techniques involve both airborne and ground-installation dispersal, and suggest an attack on fog may be economically feasible in geographic locations once subject to the whims of nature. One expert believes improved fog-dispersal techniques may one day be applied in non-aviation settings: to clear a dangerous stretch of heavily used highway for example, or perhaps just to dissipate the gloom a persistent fog can cast over a town. Among the new weapons in use, and under development and study:

- Ground seeding, achieved with colorless, odorless liquid propane gas sprayed as a mist into fog masses.
- Hydroscopic—moisture-removing—airborne seeding with microencapsulated chemicals that evaporate fog.
- Generating heat plumes (by burning smokeless liquid propane) which burn away the toughest fog.
- Spraying electrified water droplets that attract fog particles like magnets.

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Against Fog

• Evaporating fog by mixing it with clear air, using helicopters, a technique proven in Viet Nam.

To learn how science is gearing up for a full-scale attack on fog, I recently visited Hanscom Field at Bedford, Mass., and rapped with weather-expert Dr. Bernard Silverman at the U.S. Air Force Electronic Systems Division. Then I spoke with Capts. Larry Menderhall and Ted Cress at Scott AFB, Ill. Cress and Menderhall have been testing fog-dispersal concepts in Alaska, the West Coast, Europe, and elsewhere.

Three types of fog. One of the first things I learned is that a three-way attack is required. Three basic fog types —ice fog, supercooled or cold fog, and warm fog—require different techniques to make them disappear. Fog is simply a cloud of microscopic water particles that restrict visibility to 3280 feet or less. Fog forms when moist air is cooled; when humidity reaches the saturation point, tiny water droplets form.

These droplets become ice crystals in extremely cold climates. This is ice fog, a rarity. In Alaska and Greenland, where ice fogs can be a problem, it's wise to locate airports upwind from the moist heat of public housing. One way to reduce ice-fog formation is to include moisture suppressors, such as heat exchangers, on exhaust pipes. To disperse small ice-fog clouds, large fans have been used.

When air temperature is just below freezing, there are no suitable ice embryos in the atmosphere, and water droplets form in a semistable physical state. Supercooled or cold fog results. Much of the success in fog dispersal has been with this variety. On a worldwide basis, however, cold fog represents only a tiny part of the problem. About 95 percent of the fog you'll encounter in the U.S. is the warm variety (water droplets above the freezing point). Warm fog is a stable suspension of droplets in air, and Dr. Silverman says "brute force" must be used to disperse it.

Fogs are further classified by the conditions under which they form (see drawings, next page). *Radiation* fog forms when moist air is cooled by heat escaping a surface via radiation; *upslope* fog occurs where moist air moves to higher elevations and decreased pressure; and *advection* fog develops when moist air passes over a cold surface. Also, *warm-rain* fog develops when water falls into a layer of cold air. *Warm-water* fog is produced by water vapor rising into a colder air mass.

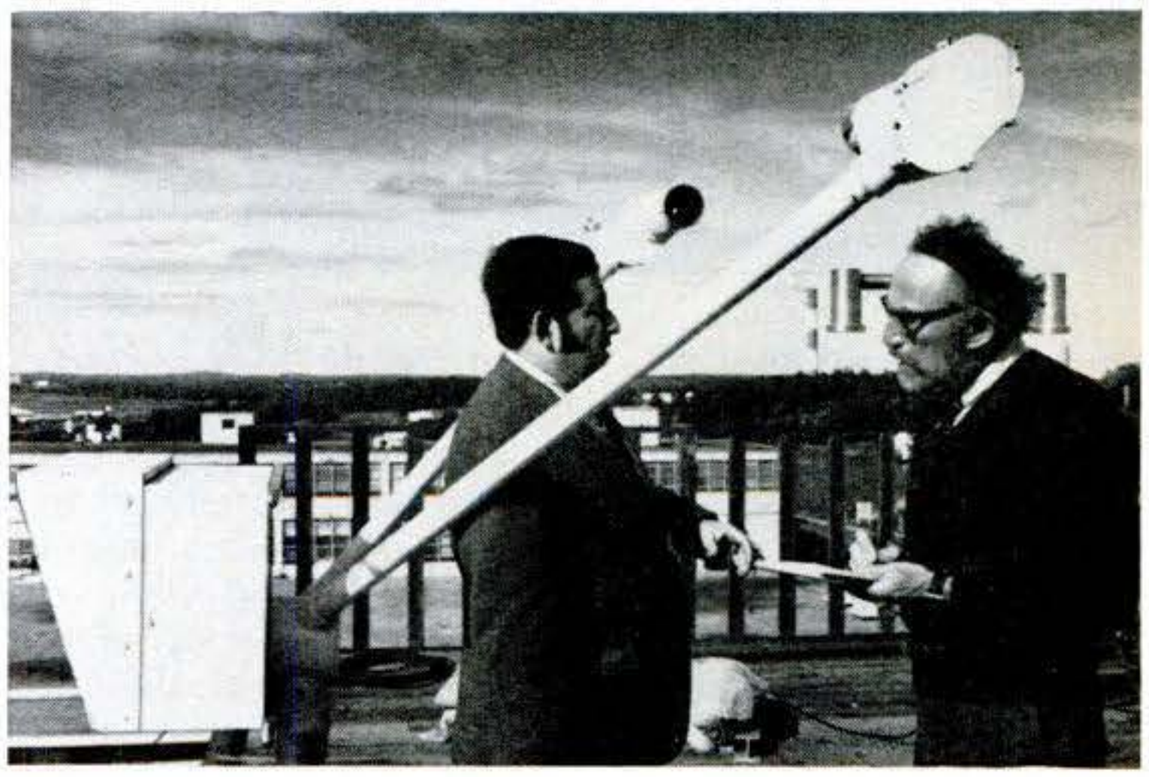
Fighting fog from the air. Let's look first at what's been going on with seeding from aircraft. Strangely enough, while early experiments in snow making and fog clearing took place in the U.S., it was the Russians who picked up the idea and did something with it.

In 1946, General Electric scientist Vince Schaefer first demonstrated that dropping dry ice into clouds emptied them of moisture and created snow. In the 1950s, the Army proved it could make holes in fog. By 1957 the Air Force Cambridge Research Lab developed a "cloud buster" by carrying liquid CO_2 in an aircraft, pouring out snow-like expanded CO_2 into cold clouds.

It worked, but unfortunately the idea wasn't hotly pursued. Dr. Silverman learned from scientific reports that by the early 1960s the Russians were already using dry-ice operationally to clear airports of fog.

Here's why the airborne-seeding technique works:

Liquid-propane burners heat air in fog-clearing tests. Natural gas can also be used. Future installations will be underground.



Dr. Silverman gives explanation of fog-measuring gear to author Kocivar (right). Unit measures fog density across 1.5 cubic feet.

Since water droplets in cold fog are not physically stable, they can easily be converted to another state: ice. The introduction of ice-forming nuclei such as CO_2 particles creates ice crystals. The crystals fall as snow and open a clearing.

Dropping out at minus-five degrees. Ice crystals can also be produced by dropping silver iodide particles to form the nuclei. Capt. Cress of the Air Weather Service points out some major problems, however. Much supercooled fog exists in the temperature range from zero to minus-five degrees centigrade, and silver iodide is not an active ice nucleant above minus-five degrees. Also, the Air Weather Service found its big four-engine turboprop Lockheed Hercules transports had to fly within 250 feet of the top of fog banks for silver iodide seeding to be effective. In hilly terrain, that's not conducive to the longevity of pilots.

Dry ice creates problems, too. In the temperature range of zero to minus-one degree centigrade, ice-crystal growth is very slow. However, the dry ice does fall quickly through the fog, creating an ice-crystal curtain, which is practical and usable.

By the mid-sixties, United Airlines got impatient with government foot-dragging in fog dispersal and started its own air-seeding operations in northwestern airports. After that the Air Weather Service began using the techniques for military bases. (Today, using various methods, 13 civilian airports in the U.S. and 11 military fields here and abroad disperse fog.)

Why did it take us from 1946 to the sixties to start using the information on hand? Dr. Silverman, a physicist at the AF Cambridge Research Laboratory, believes it was because research money was aimed primarily at development of instrument-landing systems to make bad-weather landings safe. It seemed more promising to concentrate on radio, radar, and automatic flight-control sys-

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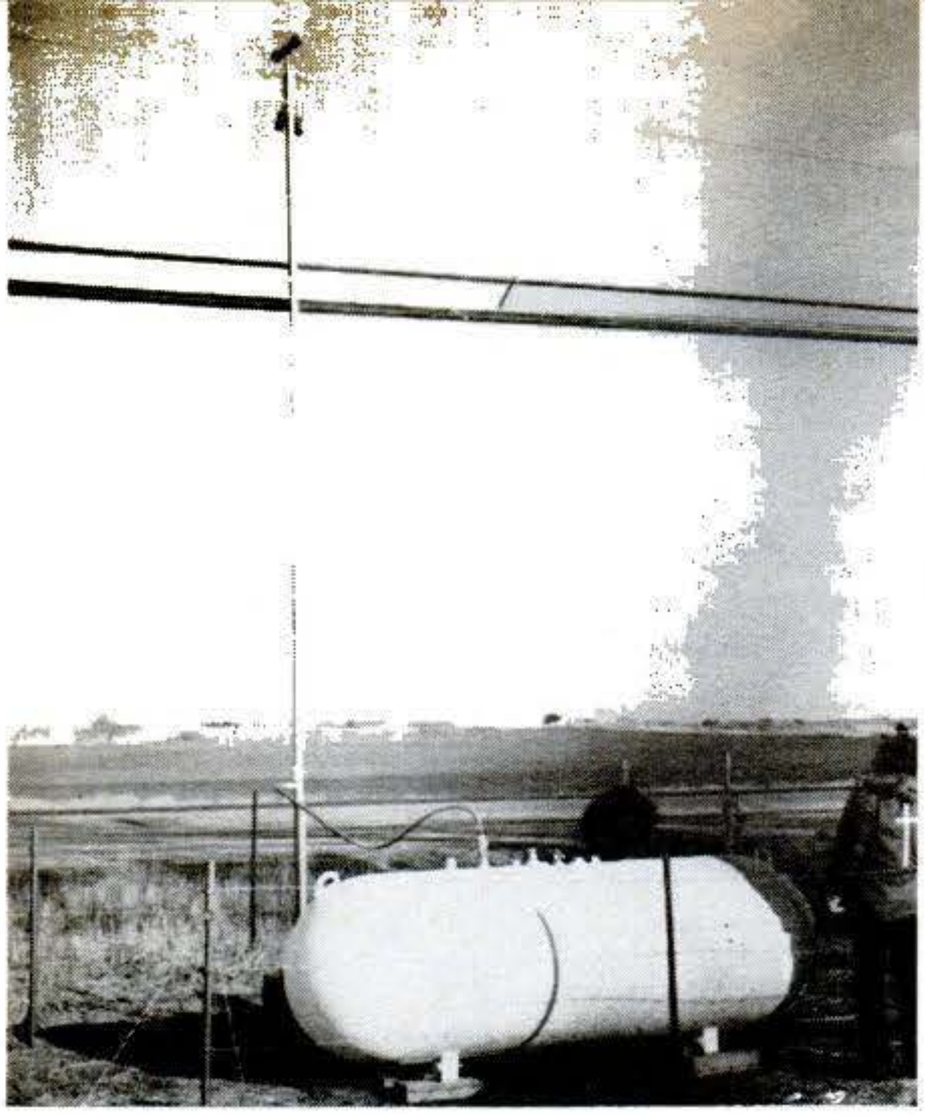
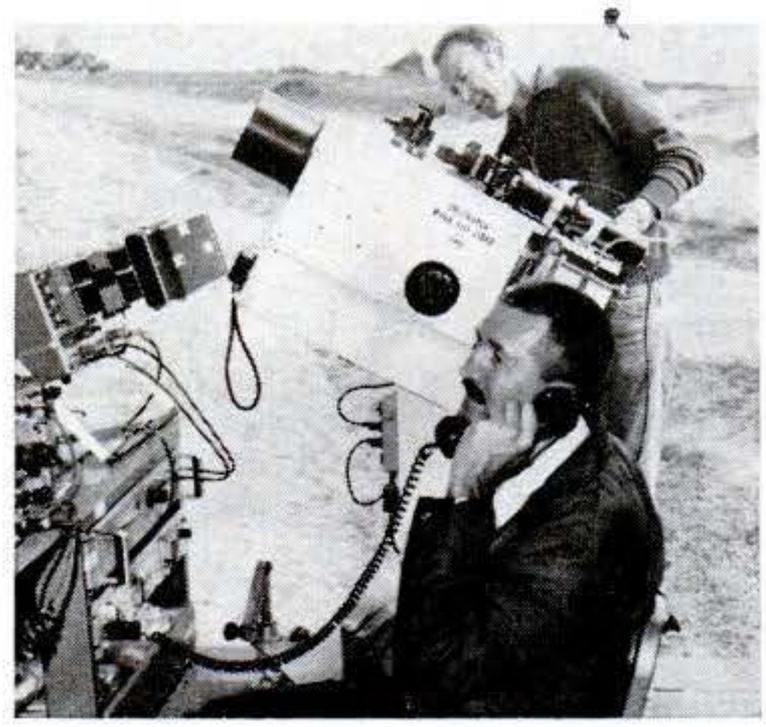


Remotely controlled tanks spray liquid propane gas into cold fog, dropping air temperature to —40 C. Fog droplets turn into ice crystals, which coat everything. Tanks, about 2000 feet apart, spray 10 gallons per hour, clearing runways in 40 minutes.



Fog density is measured by this LIDAR (light detection and ranging) unit. Light bounces off fog at 1½ times distance you can see.

tems than to attempt to clear up the air over airports.

Dr. Silverman, incidently, holds patents on methods of suppressing aircraft contrails. These vapor-trail "fogs" are formed by moisture created from burning fuel. Silverman found that by injecting sulphur dioxide into engine exhausts, the moisture particles that formed were too small to be visible. Although the particles grow larger, they are simultaneously diluted and vaporized. Result: no vapor trail.

Another type of airborne technique is required for warm fog: hydroscopic seeding. Chemicals for hydroscopic seeding are in the form of dry particles or saturated-solution droplets. As they are injected into fog, they absorb water vapor. As the air is dried, the tiny water droplets forming the fog can evaporate.

Dr. Silverman reports a technological breakthrough in hydroscopic seeding. The crystalline solid, urea, used in making adhesives and plastics, is ideal for such seeding because it is nontoxic, noncorrosive to metals, doesn't injure animals, and is even beneficial to plant life. Raw urea, however, is unsuitable because it breaks easily into submicron particles that are ineffective for clearing fog.

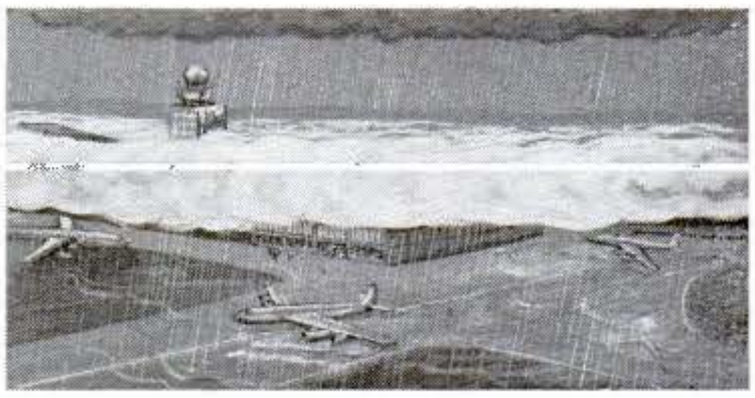
Now microencapsulation has solved this breakup problem. Recall the tiny time pills for cold remedies that release their contents over a controlled period? This micro-

[Continued on page 152]

Advection fogs are common at sea when warm moist air comes in contact with cold ocean currents, and the air is cooled to saturation point. Upslope fog can occur when warm air is forced upward along a mountainside. The air expands and is cooled.

Radiation fog forms when night cooling reduces the air's temperature. Often the fog fills areas at lower elevations.

Warm-water fog is created when rising water vapor strikes colder air and condenses. This fog may look like steam in marshes.



Warm-rain fog develops frequently at an airport when rain saturates a colder layer of air closer to the ground.

How and where fog clouds can develop

Fog is simply a ground cloud that forms when falling temperatures lower the atmosphere's ability to hold water vapor. At a critical temperature, the water vapor turns into a liquid by condensing onto condensation nuclei—minute dust particles—in the atmosphere. Fog can develop under a variety of conditions as the drawings above show.

The microscopic fog particles are spherical, from two to 50 microns in diameter. Density may range from a hazy 20 particles per cubic centimeter to a concentration 25 times as dense.

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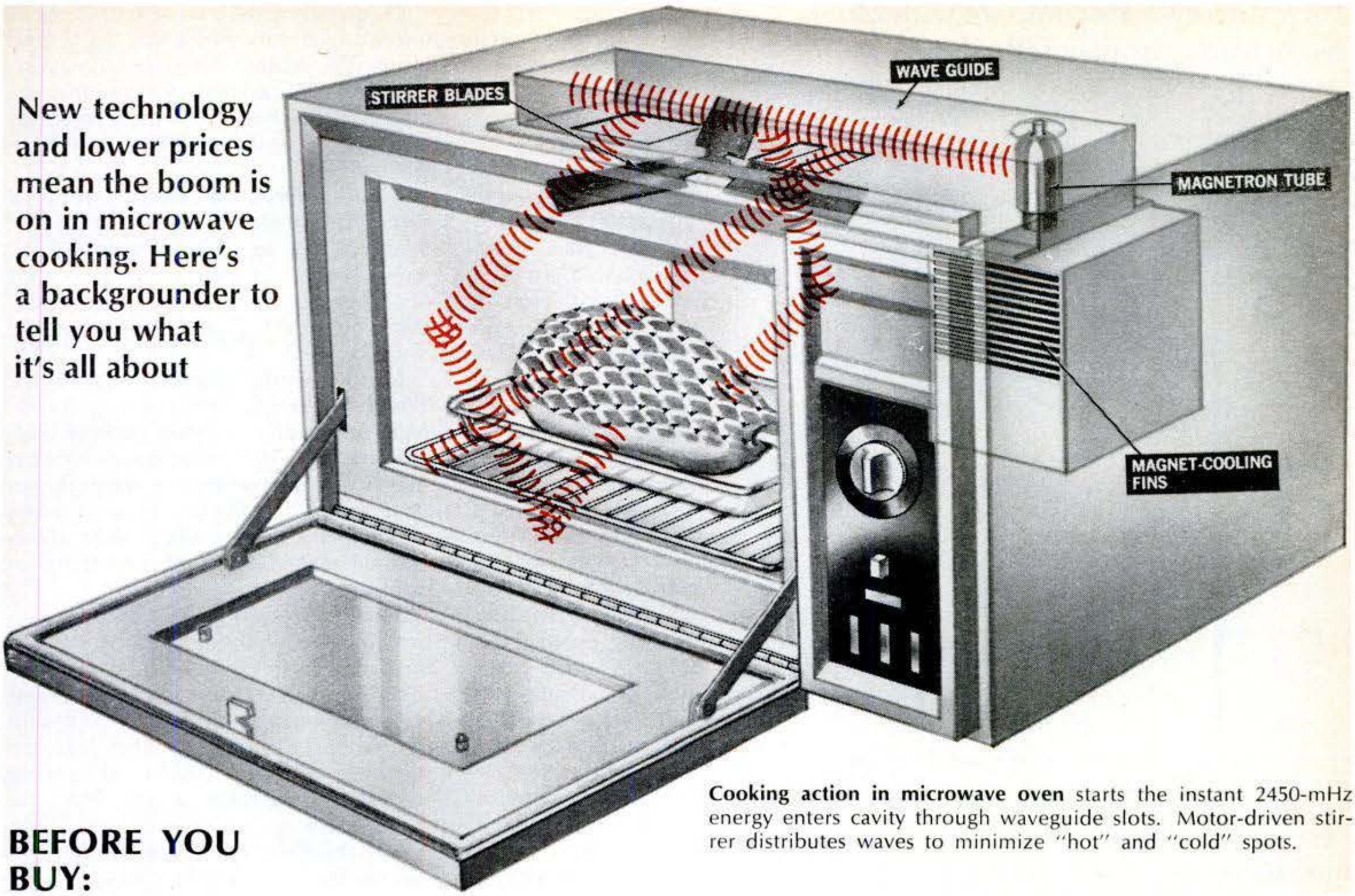
New technology and lower prices mean the boom is on in microwave cooking. Here's a backgrounder to tell you what it's all about



Cooking action in microwave oven starts the instant 2450-mHz energy enters cavity through waveguide slots. Motor-driven stirrer distributes waves to minimize "hot" and "cold" spots.

BEFORE YOU BUY:

The Facts About Microwave Ovens

By **JOHN R. FREE** DRAWINGS BY DAN TODD

A compact black box perched on a counter in my kitchen is putting a bulky four-burner stove next to it out of business. Why? Because the box, a microwave oven, has quartered the time needed to cook meals at my home.

The oven's phenomenal cooking speed is startling at first. Push a Thermador MC11's ON switch: Exhaust fans whoosh, the magnetron tube buzzes with energy, and an interior light, interrupted by 140-rpm stirrer blades, flickers eerily. Microwaves literally shake food molecules 2,450,000,000 times a second. Small food items emerge piping hot in seconds, a roast or chicken takes 15 minutes instead of one hour, a baked potato is out in four minutes.

Several recent developments in the microwave-oven industry—combined with gradually developing trends in America—have stimulated a major boom in microwave-oven sales. Among them:

- Lower cost. Last spring, Montgomery Ward offered a Japanese import for $222. A new wave of marketing activity followed. Several U.S. firms introduced import labels under their brand models; others have

Continued

Wheeled carts enable you to set up kitchen wherever there's a grounded 115-volt outlet. This is a portable Westinghouse model.

New steak grill and skillet from Litton employ ferrite-ceramic strips—preheated in oven—to sear as microwaves cook food.

Browning grill just introduced by Amana uses ironstone material to brown food. Casserole included with set prevents spattering.

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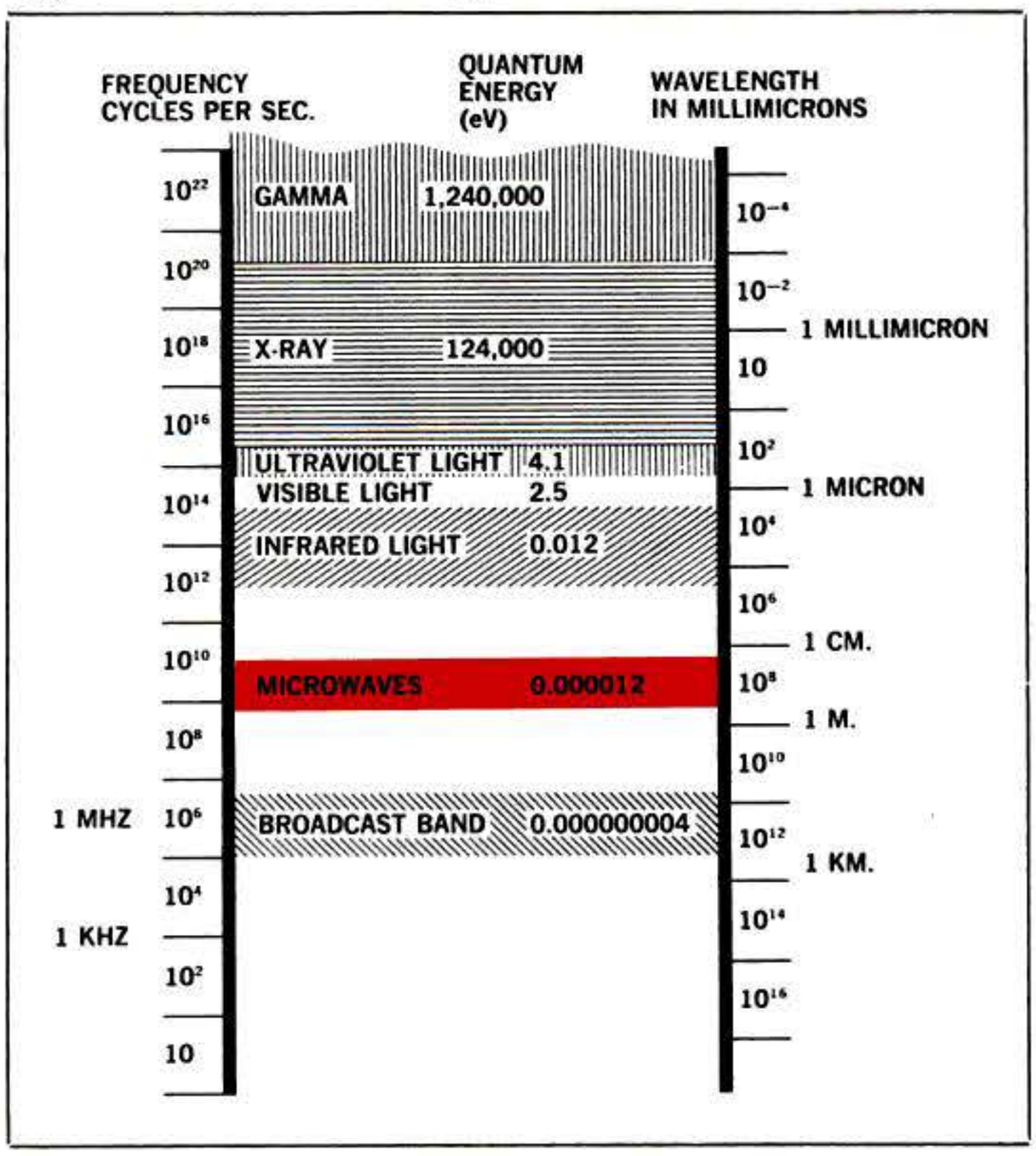
How microwaves compare with other types of electromagnetic radiation



Like TV broadcast waves, microwaves have insufficient quantum energy (electron volts) to break chemical bonds in organic material, unlike ultraviolet light, X rays, and gamma rays.

trimmed prices of domestic models.

• Better browning capabilities. Microwave ovens cook so fast that many items don't really brown, but come out gray. New models solve this problem in several ingenious ways.

• Safety. Some potential customers were worried about reports that early models were a radiation hazard. Tough new government regulations have laid that problem to rest.

• New lifestyles. Microwave ovens have always been fast. But now that's more important than ever. "Microwave cooking fits today's lifestyles," says Dan Gavalier, marketing vice-president for Litton Industries' Atherton Division, "and goes with convenience foods, irregular meal preparation, the working wife and mother."

Whatever the reason, the boom is on. Robert Bruder, president of Litton's oven division, pegged last year's industry sales at 175,000 units. By 1976, he estimates about 1.5 million of six million ranges sold annually will be microwave.

The big sellers are portable countertop units to supplement conventional cooking appliances. They operate on 115-volt, 15-amp lines. Larger free-standing ovens need 220 volts. You can build your own microwave oven from a kit (see Heathkit on chart).

PS experiments. To discover what microwaves can and can't do, I and other PS editors have been experimenting with microwave cooking, including the new browning systems now on the market. Here's what we learned:

First, microwave ovens aren't a complete substitute for conventional ovens. They do a phenomenal job on many kitchen chores, let you do a lot of things you can't do any other way. But you won't throw away your old oven.

Main advantage, of course, is speed. Tough vegetables such as artichokes, which normally take an hour of boiling, are done in four minutes. A hot-dog in a bun comes out steaming in 30 seconds—and the bun is hot, tender, and moist, too. Cakes, vegetables, many meat dishes—all are done in minutes.

Most surprising are things you probably never thought of. A stick of butter melts in 20 seconds. That serving of left-over stew will come out steaming—and not all dried out— in two or three minutes. And you can reheat in the same bowl used to store it in the refrigerator, so you don't get a pot dirty.

Capabilities such as these can change the way you do a lot of things. Do you work late and get home after dinner at times? Your wife can fill your plate at dinner time and put it in the refrigerator. Set it in the microwave oven when you get home and it will be piping hot by the time you get your hands washed.

Microwave ovens can perform these and other super-fast or off-beat cooking chores because they cook in a fundamentally different way from any other appliance in your kitchen.

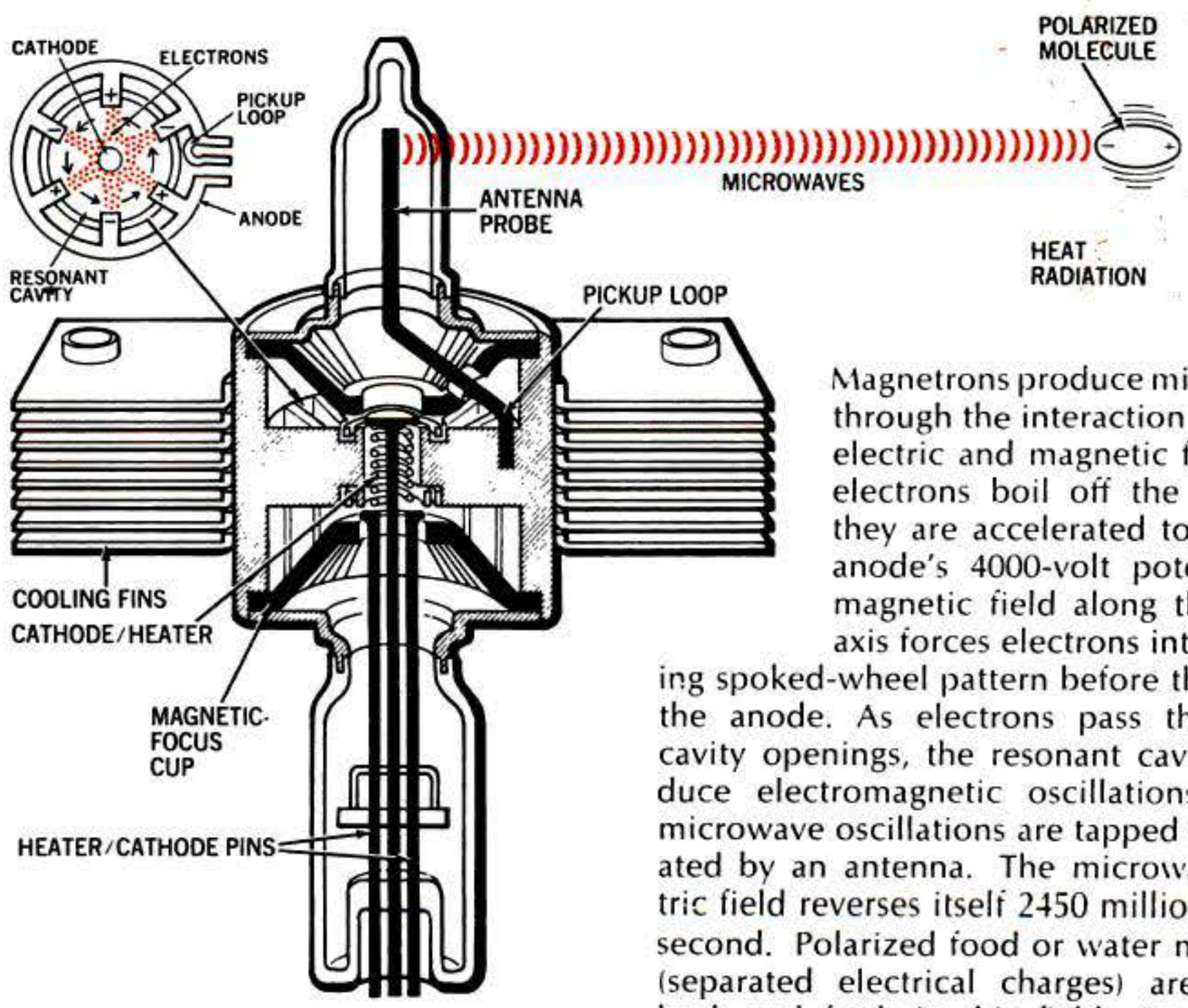
Your regular range, or conventional oven produces heat that is transmitted through the pot or air into the food.

In microwave cooking, on the other hand, very-high-frequency radio waves penetrate the food, agitate the individual molecules, and cause it to cook internally (see box). The cooking source is not a flame or a resistive-electric heating element, but a magnetron (see drawing)—a high-frequency radio tube designed for use in radar during WWII.

Although it is an electronic appliance, don't expect to find a maze of tubes or transistors in a microwave oven. Home-use countertop ovens have only one tube, the magnetron oscillator, and a high-voltage power supply for the tube.

A metal waveguide feeds microwave energy from the magnetron into the metal-lined oven cavity. A mode stirrer, metal fan blades, is usually positioned between the cavity and wave-

How magnetrons generate microwaves and cook food



Magnetrons produce microwaves through the interaction of strong electric and magnetic fields. As electrons boil off the cathode, they are accelerated toward the anode's 4000-volt potential. A magnetic field along the tube's axis forces electrons into a rotating spoked-wheel pattern before they reach the anode. As electrons pass the anode cavity openings, the resonant cavities produce electromagnetic oscillations. These microwave oscillations are tapped and radiated by an antenna. The microwave electric field reverses itself 2450 million times a second. Polarized food or water molecules (separated electrical charges) are flipped back and forth in this field. Tremendous molecular friction produces heat.

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Buyer's guide to countertop microwave ovens

Manufacturer or Brand	Model(s)	Price	Exterior Dimensions (H, W, D In.)	Oven Cavity Dimensions (H, W, D In.)	Oven Capacity (Cu. Ft.)	Weight (Lbs.)	Browning Element	Cooking Power (RF Watts)	Power Requirements: Volts	Power Requirements: Watts	Timer Range (Mins.)	Warranty (Parts, Labor) (Yrs.)	Miscellaneous
ADMIRAL	PEM 2436	$400	14¾x24x16½	8⅛x15x12	.85	70	NO	600	115	1400	14	1 (tube, 4)	opt. roll cart
AMANA	R-1J	350	14⅞x18¼x23	8x15½x13	.93	81	NO	660	115	1600	15	5	
	R-2	395	14⅞x18¼x23	8x15½x13	.93	81	NO	660	115	1450	13	5	
	RR-4	450	15x22¾x17¼	9⅛x14⅝x13⅜	1.0	87	NO	660	115	1450	5, 30	5	two timers
CALORIC	MPK 106	380	14⅞x18¼x23	8x15½x13	.93	81	NO	660	115	1450	12	1 (tube, 4)	
FRIGIDAIRE	RCM 375	370	15x18¼x22½	8x15½x13	.93	83	NO	660	115	1600	12	1	
GENERAL ELECTRIC	JET 70	260	15⅛x18¾x16⅞	6⅞x10¾x10¾	.46	72	NO	550	115	1200	15	1 (tube, 2)	
	JET 80	360	15¾x22x17⅞	7¾x13¾x13¾	.85	92	NO	570	115	1320	25	1 (tube, 2)	
HARDWICK	EF 288-400	542	14¾x24x16½	8⅝x15x12	.9	70	NO	600	115	1400	14	N/A	
HEATHKIT	GD-29	380*	15⅛x25½x14¾	7⅞x15½x14	1.0	75	NO	650	115	1600	35	¼ (tube, 2)	*kit only
HITACHI	MRK-621	N/A	17x17¾x17⅝	8½x13⅜x10¾	.67	90	NO	550	115	1200	25	1 (tube, 2)	
HOTPOINT	RE 910	260	15⅛x18¾x16⅞	6⅞x10¾x10¾	.46	67	NO	550	115	1200	15	1 (tube, 2)	
	RE 920	350	15¾x22x17⅞	7¾x13¾x13¾	.85	86	NO	570	115	1320	25	1 (tube, 2)	
LITTON	401	349	15x24¼x16⅞	9x14⅛x16	1.2	70	NO	600	115	1460	20	1 (tube, 2)	
	402	399	15x24¼x16⅞	9x14⅛x16	1.2	70	NO	600	115	1460	28	1 (tube, 2)	auto defrost
MAGIC CHEF	MC-30	399	16⅛x25¼x20⅛	9⅝x14½x13½	1.0	80	NO	650	115	1650	15	1	no stirrer
MGA	ET-60	350	16⅜x24x20⅜	8⅞x15x12⅞	1.1	103	NO	600	115	1350	45	parts 2, labor 1	
MODERN MAID	DMO 500	399	15x24¼x16⅞	9x14⅛x16⅛	1.2	70	NO	600	115	1460	28	1 (tube, 2)	auto defrost
MONTGOMERY WARD	8093	250	14¾x18½x12½	6½x10¾x10¾	.6	75	NO	550	115	1200	15	N/A	opt. roll cart
	8092	350	15¾x22⅛x17½	7¾x13¾x14½	.9	89	NO	600	115	1400	25	N/A	opt. roll cart
	8094	450	16½x23⅝x18⅞	7⅝x13¾x14⅜	.9	100	YES	650	115	1400	25, 25	N/A	two timers
PANASONIC	NE-6300	350	14⅞x21¼x18½	7⅞x13x10⅞	.64	87	NO	600	115	1300	10	N/A	
SANYO	EM 8000	380	16⅜x20⅞x19⅛	7½x16⅞x10¼	.75	88	NO	650	115	1500	25	N/A	
SHARP	R-5000	270	15⅛x18½x17⅛	6⅞x10¾x10¾	.46	67	NO	550	115	1200	15	2	opt. roll cart
	R-6300	340	15¾x22⅛x17⅜	7⅝x13¾x13½	.82	86	NO	650	115	1400	26	2	
	R-6500	400	15¾x22⅛x16⅜	7⅝x13¾x13½	.82	86	NO	650	115	1400	25	2	
	R-6600	460	16½x23½x19	8¼x13¾x14½	.95	100	YES	620	115	1400	25, 25	2	two timers
TAPPAN	56-1139	315	14¾x24x16½	8¾x15x12	.91	92	NO	575	115	1320	28	1	
THERMADOR	MC 11	499	12⅝x23⅝x14½	7x16x12	.78	81	YES	700	115	1750	35	1 (tube, 2)	
	MTR 12	525	12¼x23⅝x13¾	9⅞x16x11½	1.1	81	YES	700	240		35	1 (tube, 2)	
TOSHIBA	ER 625	360	17½x17x17¾	7⅞x13x9⅞	.6	75	NO	600	115	1250	12	2	opt. roll cart
	ER 722 BT	450	16⅛x23⅝x18⅞	8⅜x15x15	1.1	99	NO	650	115	1350	35	2	opt. roll cart
WELBILT	1000	200	12⅝x17½x12½	6⅛x10¼x10¾	.39	35	NO	425	115	900	20	1	no window
	2000	230	12⅝x17½x12½	6⅛x10¼x10¾	.39	37	NO	425	115	900	20	1	light, oven chart
WESTINGHOUSE	KM 420	399	14⅞x18¼x23	8x15½x13	.93	91	NO	660	115	1600	14	2	opt. roll cart
	KM 520	499	15x23¾x17	9⅛x14⅝x13⅜	1.0	103	NO	660	115	1600	30	2	opt. roll cart

ADDRESSES: Admiral, 3800 Cortland St., Chicago 60647. Amana, Amana, Iowa 52203. Caloric, Topton, Pa. 19562. Frigidaire, Div. of General Motors, Dayton, Ohio 45401. General Electric, Appliance Park, Louisville, Ky. 40225. Hardwick Stove, Cleveland, Tenn. 37311. Heathkit, Benton Harbor, Mich. 49022. Hitachi, 48-50 34th St., Long Island City, N.Y. 11101. Hotpoint, Appliance Park, Louisville, Ky. 40225. Litton, 2530 N. Second St., Minneapolis 55411. Magic Chef, Cleveland, Tenn. 37311. MGA, 7045 N. Ridgeway Ave., Lincolnwood, Ill. 60645. Modern Maid, Chattanooga, Tenn. 37401. Montgomery Ward, 619 W. Chicago Ave., Chicago 60607. Panasonic, 200 Park Ave., New York City 10017. Sanyo, 51 Joseph St., Moonachie, N.J. 07074. Sharp, 10 Keystone Plaza, Paramus, N.J. 07652. Tappan, 250 Wayne St., Mansfield, Ohio 44902. Thermador, 5119 District Blvd., Los Angeles 90022. Toshiba America, 41-06 Delong St., Flushing, N.Y. 11355. Welbilt Stove, 57018 Flushing Ave., Maspeth, N.Y. 11378. Westinghouse Electric, 246 E. 4th St., Mansfield, Ohio 44900.

guide to help distribute the energy.

Stirrers reduce so-called hot and cold spots in ovens by constantly shifting peaks and nulls in the microwaves around the cavity. Good oven design minimizes hot and cold spots.

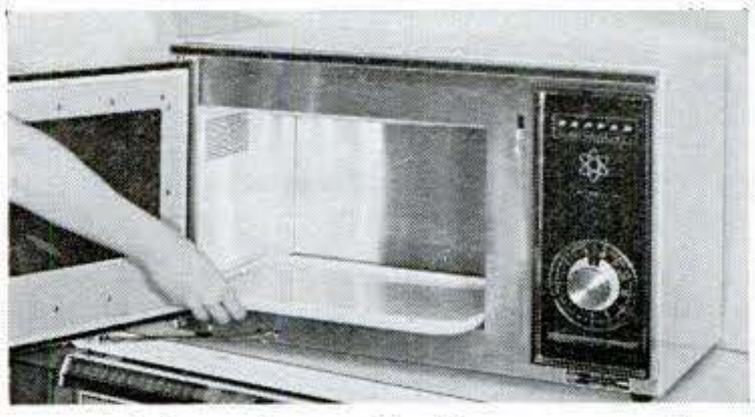
The electromagnetic radiation used by the microwave oven is radio energy. It's called microwave radiation because of the extremely short wavelength (or high frequency) used. Actual wavelength at the 2450 mHz freqency is about five inches—that's above the UHF television frequency and below infrared light in the electromagnetic spectrum (see illustration).

Microwaves are *non-ionizing* radiation; unlike *ionizing* radiation such as X rays and gamma rays that have what physicists call sufficient quantum energy to break chemical bonds and cause chemical changes at the molecular level.

Nevertheless, federal legislation that went into effect Oct. 6, 1971, limits the amount of microwave energy leaking out of the oven to very low levels. Permissible standards now are one milliwatt per square centimeter at the factory and 5 mW/cm² thereafter, measured two inches from the oven. Some manufacturers protested that the new standard was too strict, but all have refined their designs for the necessary certification label. (Some ovens may be available yet that meet only the older standard, but will not have a certification on the label.)

Blocking leakage. Doors on microwave ovens are designed to help meet the standards by confining energy to the cavity. Door seals using metal-

[Continued on page 161]



Oven shelves elevate food so waves reflecting from cavity bottom can cook. Shelves in most ovens, like this Tappan, are removable.

Automatic defrost feature in Litton's 402 cycles oven on and off. Frozen food heats enough to thaw, but does not begin to cook.

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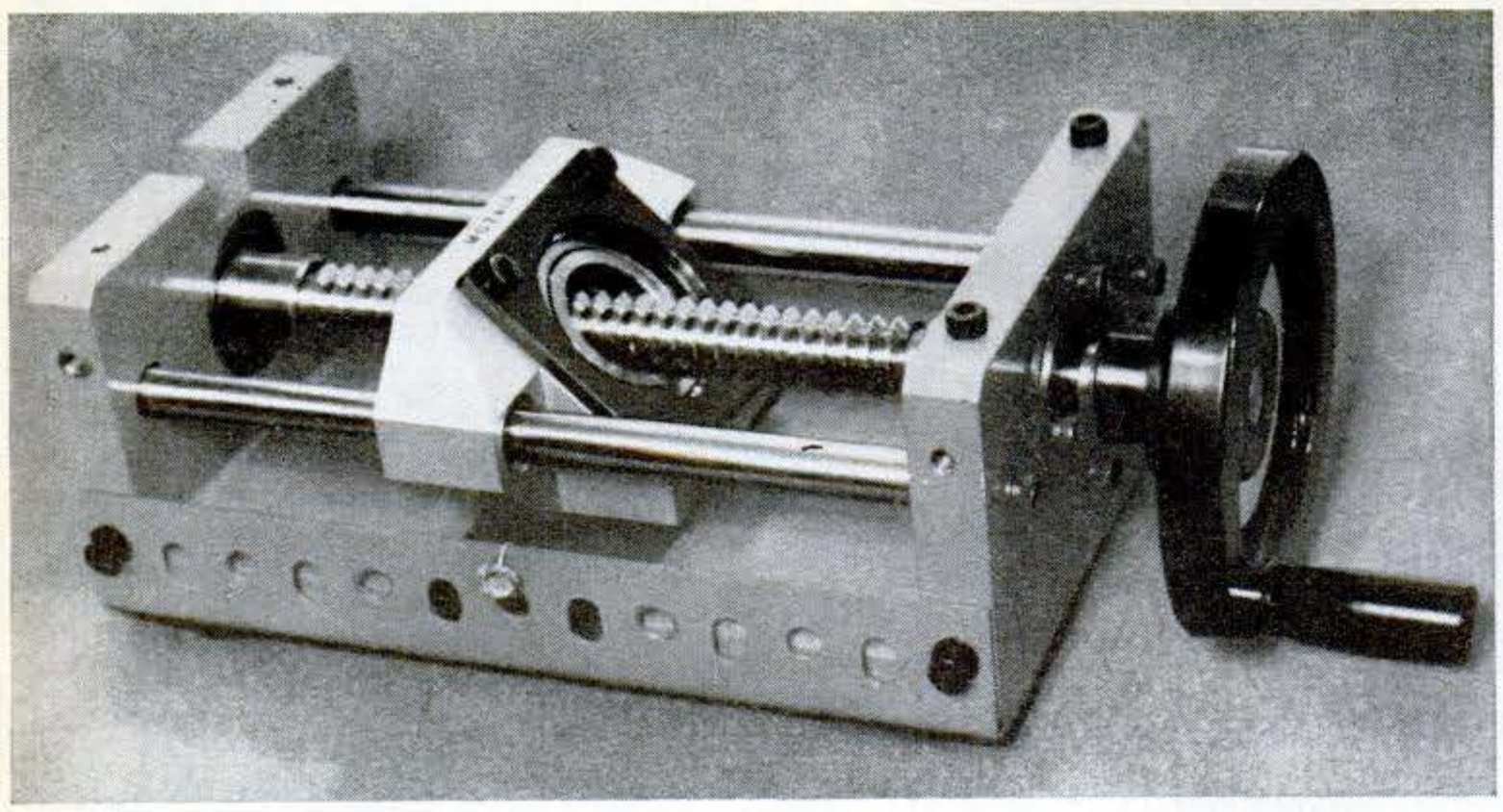
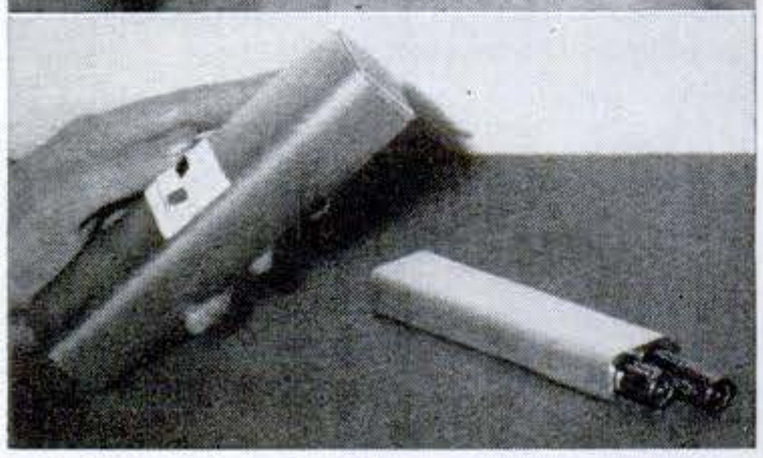
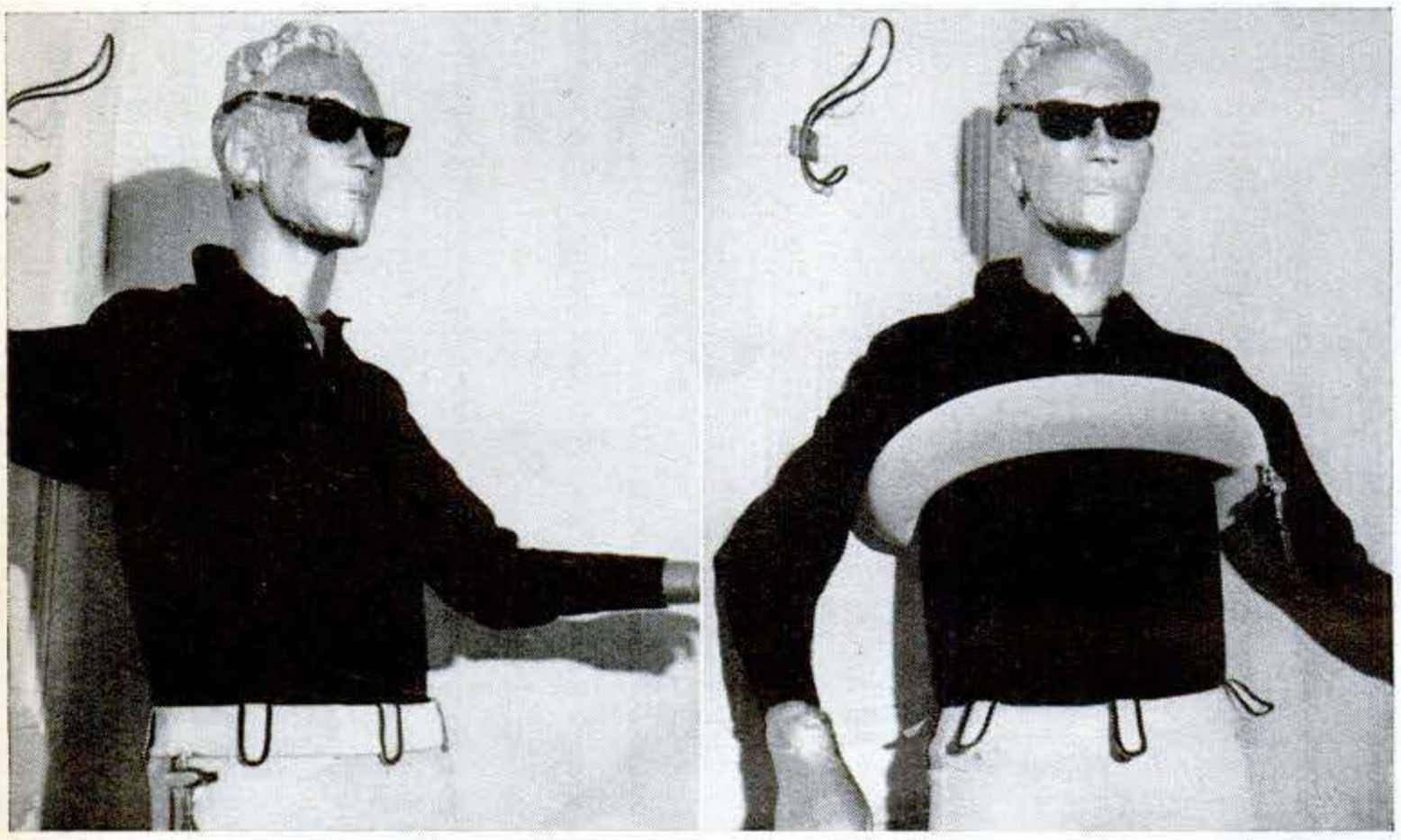


No-backlash leadscrew for precision machine tools has tilted ballbearing. Inner race seats flat against faces of tapered thread and rotates with it, with no play. Outer race is solid with the tool carrier or work slide and moves on guide rails.



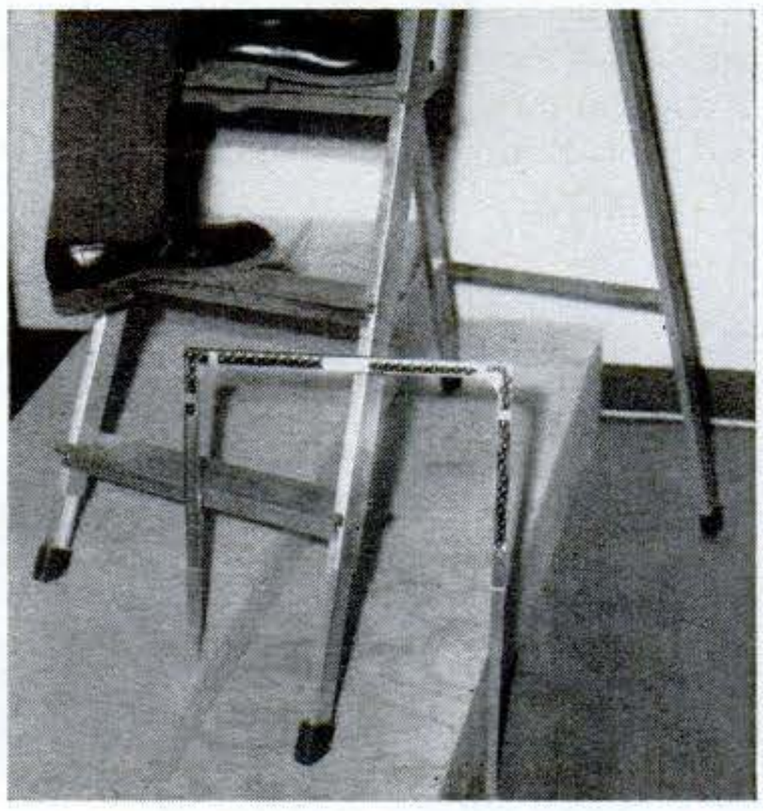
Miniature heat/cold generator supplies either at flick of switch to soothe tired muscles, ease pain of burns, insect bites. Device uses two dry cells, operates on Thompson effect, producing heat or cold depending on polarity of applied voltage.



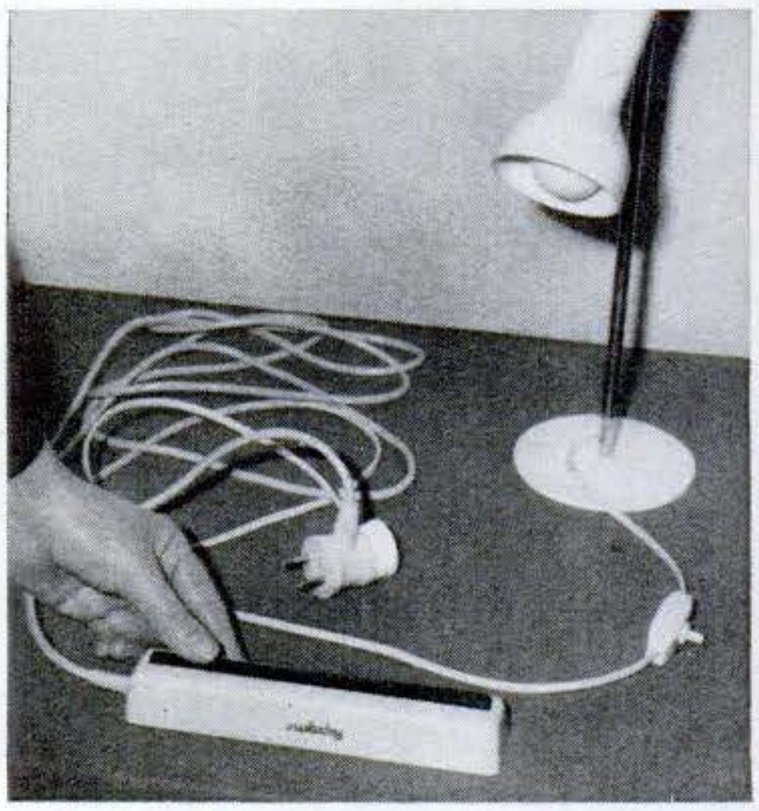
Life saver stows in belt. When swimmers in trouble pushes button, it releases pressurized CO^2 from small capsule in pocket. Belt inflates, unsnaps retaining loops, then rides up over swimmer's chest for buoyancy.

12 clever gadgets from a new INTERNATIONAL

Wristwatch flashlight clips to strap, snaps up to illuminate dial when released. Its tiny bulb is powered by a silver-dioxide battery, goes on automatically when unit flips. With a two-way prism the light can also be used for map-reading and keyhole probing.



Self-leveling ladder has telescopic leg-ends interconnected by bicycle chain through hollow rung. When ladder is set on slope, chain rolls freely, letting one leg rise as other drops. But stepping on ladder jams chain in square tube corners, locking legs.



Bar switch for bedroom lamp eliminates groping in the dark. Just put where your hand falls naturally. A touch on any part of nine-inch bar operates on-off switch. An intermediate adapter plug allows switch to be connected to any light or appliance.

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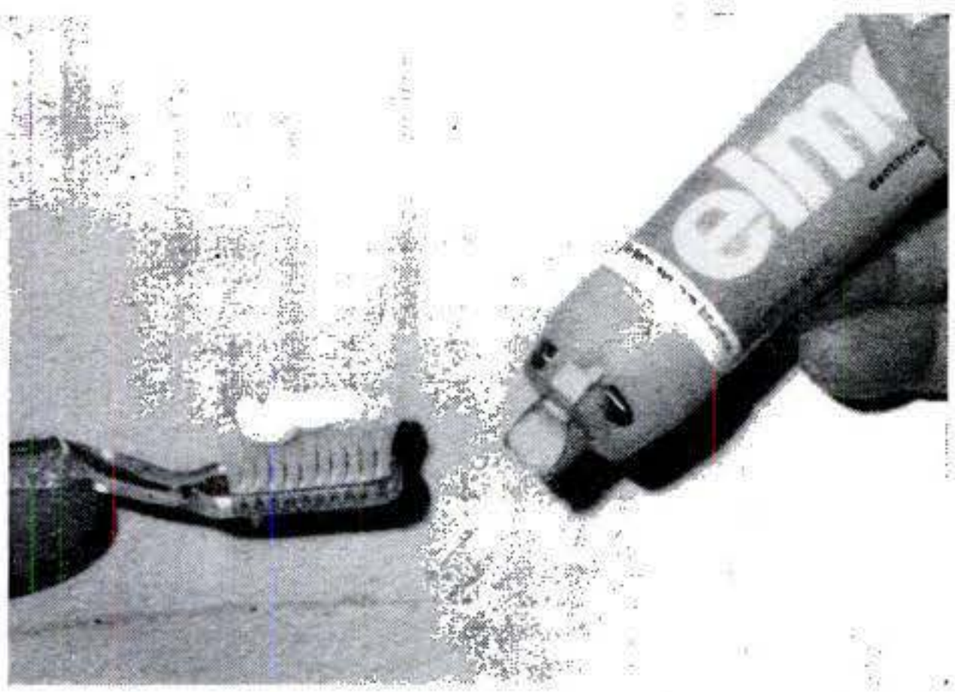
Bottle-hanger for auto, boat, or bar lets you suspend partly finished soda bottles and seal them, too, with just one hand. You press the open mouth against a rubber ball rolling on an axial pin, then swing bottle down so neck is gripped by plastic shoulders.



Capless toothpaste tube permits one-handed application, seals instantly when you stop squeezing. Rubber tube in the flat nozzle is normally pinched closed by tensioned jaw, which opens when tube is squeezed. Other uses: shaving cream and shampoo dispensers.

Ski trainer lets you practice all ski body movements at home. Rear ends of practice skis are on rollers that glide arc-like over curved tube at back of tilted quadrant platform. Springs give self-centering action to provide resistance. Ski tips are carried on ball-joints on a swiveling beam that allow shuffling or independent rocking movements.

INVENTORS' SHOW

A canny selection from Geneva's first annual exhibition of inventions by PS's European Editor, David Scott

Pay-as-you-push luggage trolley rolls freely when empty. But as soon as you load a suitcase on front-hinged platform, weight trips spring-loaded brake that clamps rubber tire of one of back wheels. To move luggage, you must free brake by inserting coin.

Swing-out auxiliary car light fitted to right rear fender helps offset glare of oncoming headlights by illuminating edge of road, where driver can fix gaze. At tail of car it's masked from other motorists, can't dazzle them. Light is controlled from dash.

Instant winter-grips can be used where studded tires can't. Device has eight spiked crampons on curved steel arms that can swing over tread for sure grip on snow and ice. Changing position takes 30 seconds; springs hold arms extended or retracted.

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Riding the Shuttle to the Bottom of the Sea

An elevator to the bottom of the sea? Our reporter takes a ride in one — first of its kind — to see how oilmen may soon be hooking up to deep, sea-floor wells.

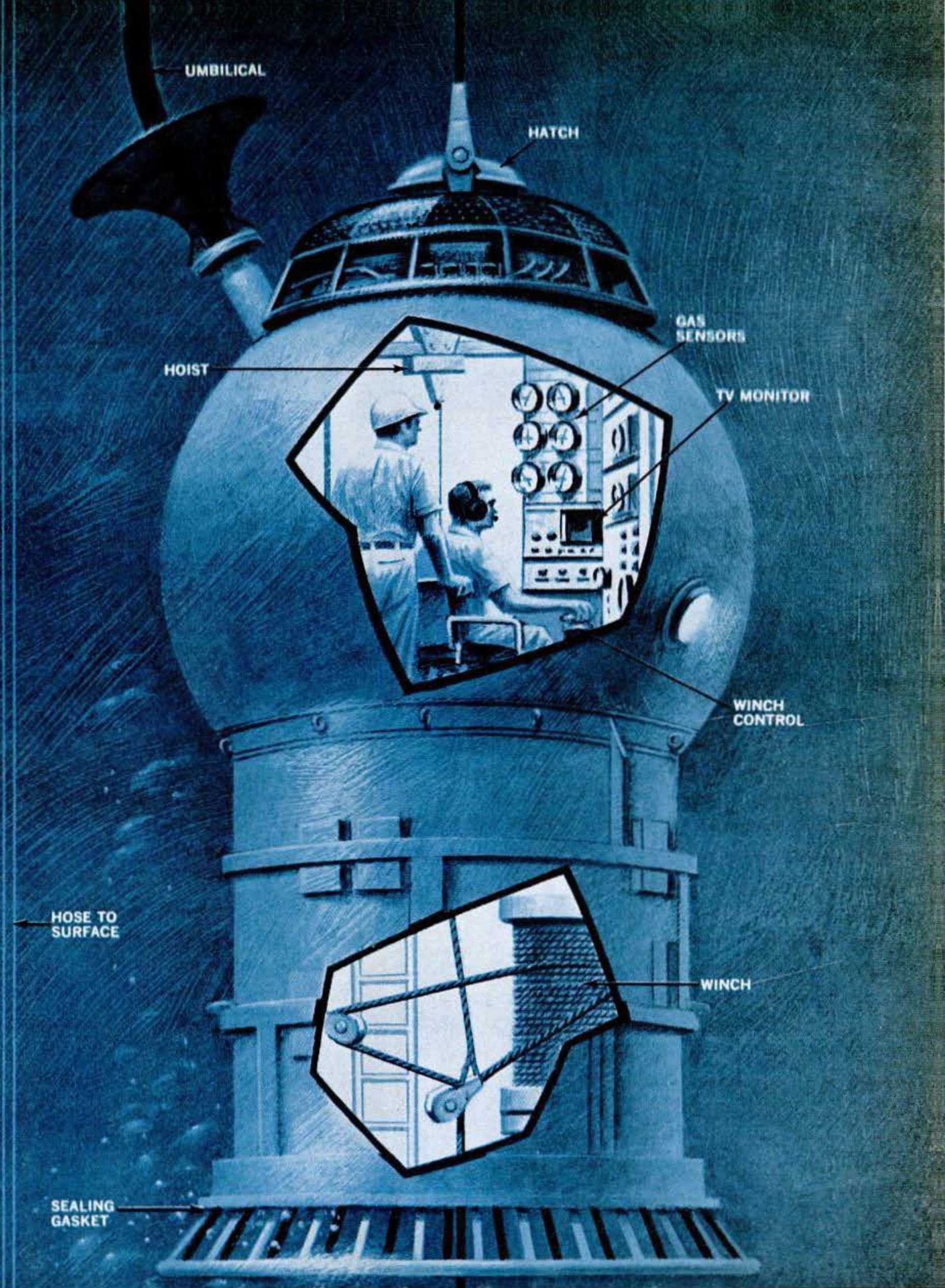
By ROBERT GANNON

DRAWING BY HOWARD KOSLOW

It was the size of a Volkswagen bus, was crammed with instruments, tools, gauges, and levers — and smelled of wet steel. Down between the captain's feet nestled a five-inch port; above his head a television camera watched; and off to his right, for some reason nobody could explain, a wallet-size picture of the Mona Lisa peered at all of us.

I sat on a coil of cables, trying to keep out of the way, and down below me, curled up in the lower hatch, the other member of the crew, Ron Bell, stared down through the bottom port. The temperature was edging to 90 degrees, and whenever I moved suddenly, drops of sweat fell down on him. He didn't mind — he was used to it, he said.

We were in a diving bell, a first-of-its-kind submersible that promises to work a major change in the offshore oil industry. We were 100 miles southeast of New Orleans,



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heading down toward the undersea snout of an oil well more than 300 feet below.

Three days earlier, the well – drilled months before – had been hooked to oil lines, and soon would be producing oil. This was the deepest underwater well ever completed – and what made it possible was this submersible capsule.

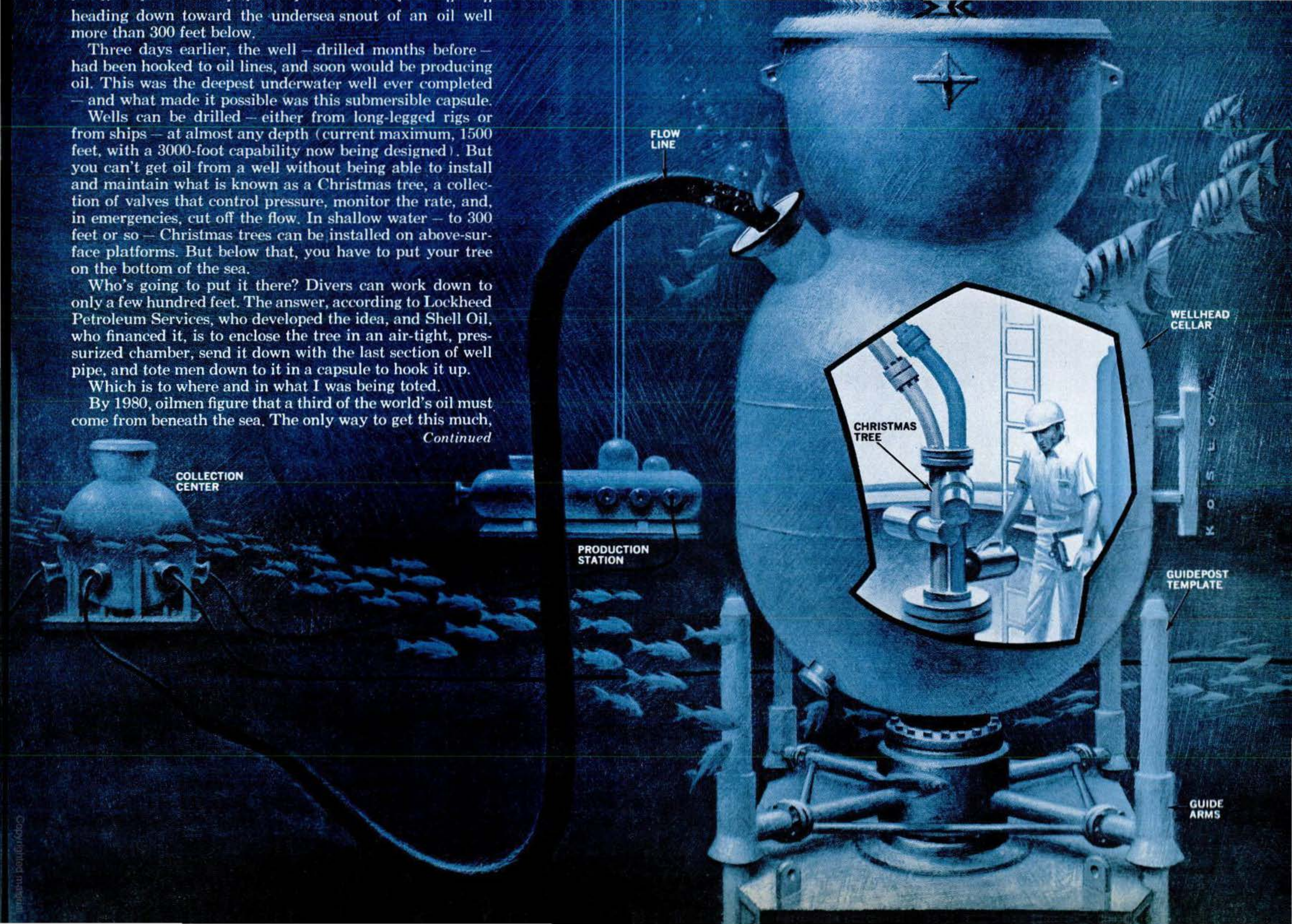
Wells can be drilled – either from long-legged rigs or from ships – at almost any depth (current maximum, 1500 feet, with a 3000-foot capability now being designed). But you can't get oil from a well without being able to install and maintain what is known as a Christmas tree, a collection of valves that control pressure, monitor the rate, and, in emergencies, cut off the flow. In shallow water – to 300 feet or so – Christmas trees can be installed on above-surface platforms. But below that, you have to put your tree on the bottom of the sea.

Who's going to put it there? Divers can work down to only a few hundred feet. The answer, according to Lockheed Petroleum Services, who developed the idea, and Shell Oil, who financed it, is to enclose the tree in an air-tight, pressurized chamber, send it down with the last section of well pipe, and tote men down to it in a capsule to hook it up.

Which is to where and in what I was being toted.

By 1980, oilmen figure that a third of the world's oil must come from beneath the sea. The only way to get this much,

Continued



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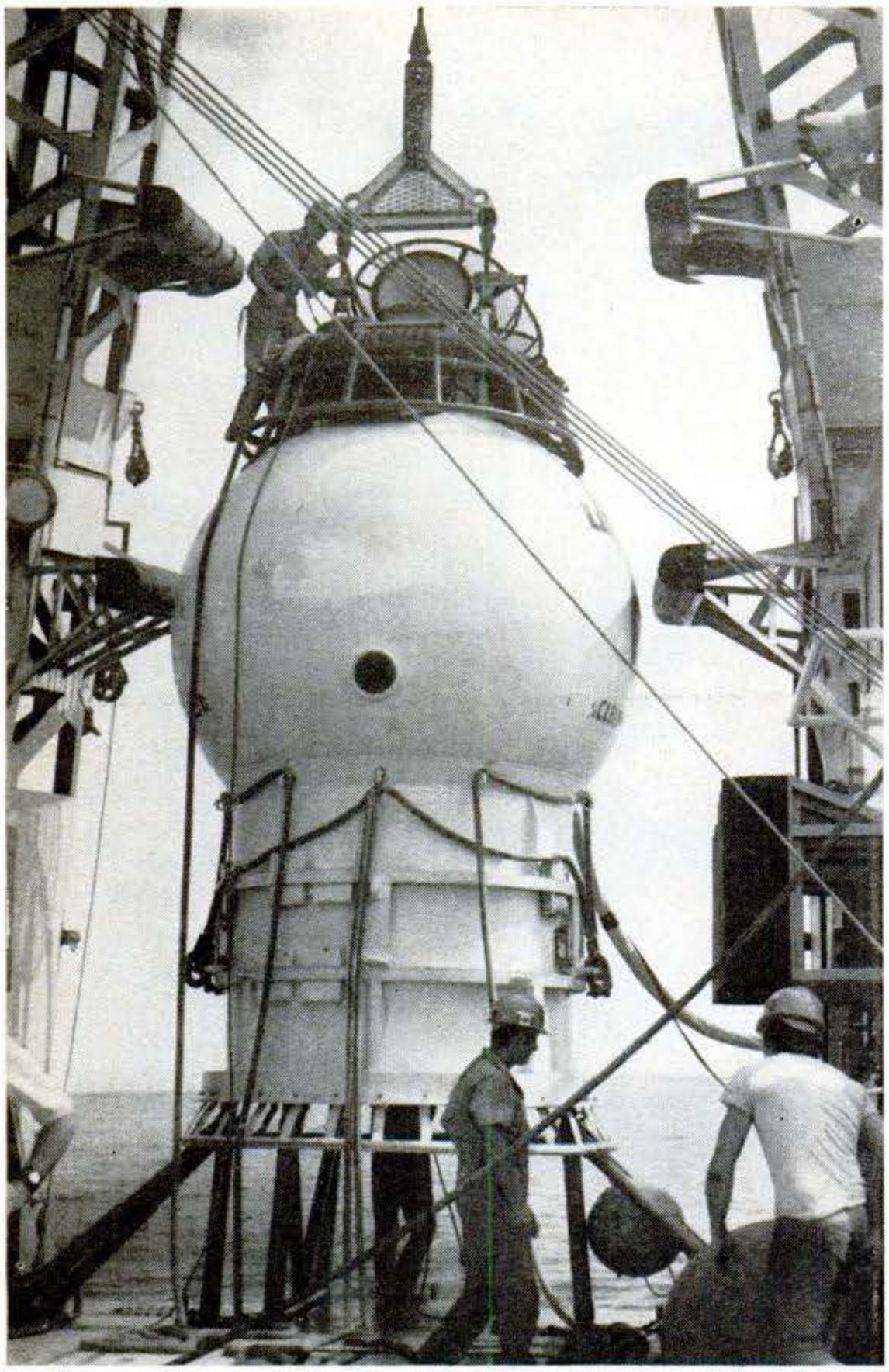


Workmen check top hatch on service capsule just before submergence. Operators dive in bulbous section, isolated from water-filled tubular section until unit mates with wellhead.

Capsule-captain Larry Gentry and author Robert Gannon (left) watch cable-tension indicators and other gauges as submersible descends slowly toward the ocean floor.

obviously, is to wade out to deeper water. But that Christmas-tree problem stymied them.

Enter John Hopkins, vice-president of Lockheed Petroleum Services Ltd. About 1965, he recalls, he visited a friend in Lockheed's Ocean Systems Division. "We were trying to think of something underseas that would fill a real need and make a lot of money doing it. And then we suddenly came upon the idea of putting a can on the bottom and matching it with another can, a diving bell—and then some real work could be managed down there."

By whom? Oilmen, they figured. And after they convinced the company to build a prototype and test it, Shell agreed to buy the first commercial model.

What emerged was a two-sectioned enclosure that, when mated, looks something like a dumbbell with a fat middle. The 30-foot bottom section, the wellhead chamber, pumped and filled with air at about surface pressure, stays on the sea floor forever. The top section, the service capsule, runs up and down like an elevator, winching itself down a guide cable. When no longer needed, it leaves for jobs elsewhere, to return only if something goes wrong below and someone has to go down to fix it.

"One thing that worried us a little was the seal, the ring where the two sections mate," says Hopkins. "But we found that the outside pressure is so great, submerged, that you could hardly dynamite the sections apart. One time during testing, in fact, we gathered a whole mess of barnacles and cemented them all over the seal—then topped it off by running a couple of half-inch ropes across the opening. And still it sealed."

Other worries were equally groundless, the problems minor. Today, all that is needed, Lockheed says, is to train crews and work out the technical bugs. Otherwise, the system is ready for mass use—and that will mean opening virtually the whole ocean to the oilmen.

Problems with the Subsea system are minor; but as you climb up into the bell and are clamped in and hear the air start to circulate around you, you can't help thinking about them.

Roughest part of a dive. Oddly enough, I found, this happens before you even submerge. Aboard ship the bell is cradled in a huge yoke that lowers it, slowly to the surface, with the divers sealed aboard. The trouble is, the ship is rocking, and that five-minute swing-out from the stern gets pretty bumpy because the cradled capsule can swing only a little before it hits the holding arms.

During that first part of the dive, the skipper, 36-year-old Larry Gentry (who is also Lockheed's chief project engineer for the system), slowly increased the cabin pressure to 22 psi, seven more than sea-level pressure. For a half-minute we all sat there swallowing, equalizing.

Other than that, though, and watching gauges and making minor adjustments, Gentry had relatively little to do. Topside engineers were monitoring our pressure and oxygen/carbon dioxide ratio, and watching us through closed-circuit television as well. We were hooked to them via a six-inch umbilical, through which ran the monitor wires plus hydraulic lines and two air lines—fresh air feeding in, stale air going out.

Gentry didn't even have to steer. Couldn't have if he wanted to; there's no wheel. The vehicle simply follows the guide cable down.

Down into the blue. When the capsule enters the water, two things happen: Light coming in through the ports abruptly changes to blue. And the world stops shaking and begins to gently rock. "When the water is choppy," explained Gentry, "the entry is smooth: the choppiness seems to flatten out the swells."

The well lay some 250 feet horizontally behind the boat, and we were traveling downward at an angle. We wound ourselves along; a winch in the bottom skirt pulled in the cables. The cable grumbled and strained, and every so often snapped into place, sending a shudder through the capsule. And me.

Ron Bell, the guy lying in the pit below me, was staring downward, face against the port, hands shielding his eyes from inside light, watching the cable. He was particularly attentive because, the day before, the cable somehow got looped around a projection, and the crew worked almost two hours to untangle things. And if they hadn't?

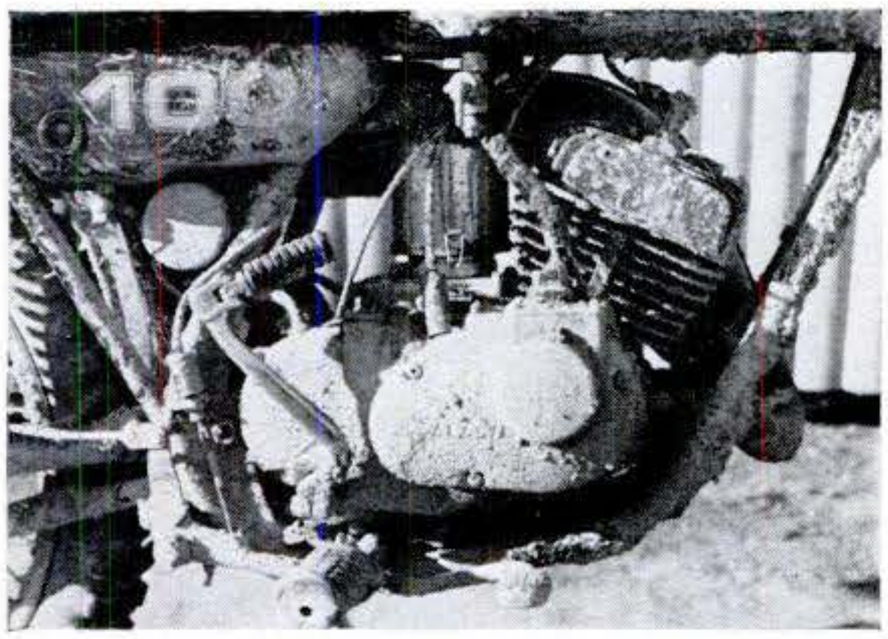
[Continued on page 145]

10-Speed Kawasaki G-4: a Gear for Everything

Whether you're going up a steep slope or cruising the highway, the dual-range G-4 is ready

By RAY HILL

Author relaxes aboard G-4 after four-hour test ride over rough off-road terrain. Elevated front fender keeps the front wheel from clogging with mud.



Engine is reliable and starts easily. Where's the carb? Covered by a side plate that protects it from mud and water. Little power plant runs about 100 miles per tank filling.

Electrical kill switch next to throttle lets you stop the engine quickly. Lever in middle of photo controls the dual-range mechanism inside gearbox.

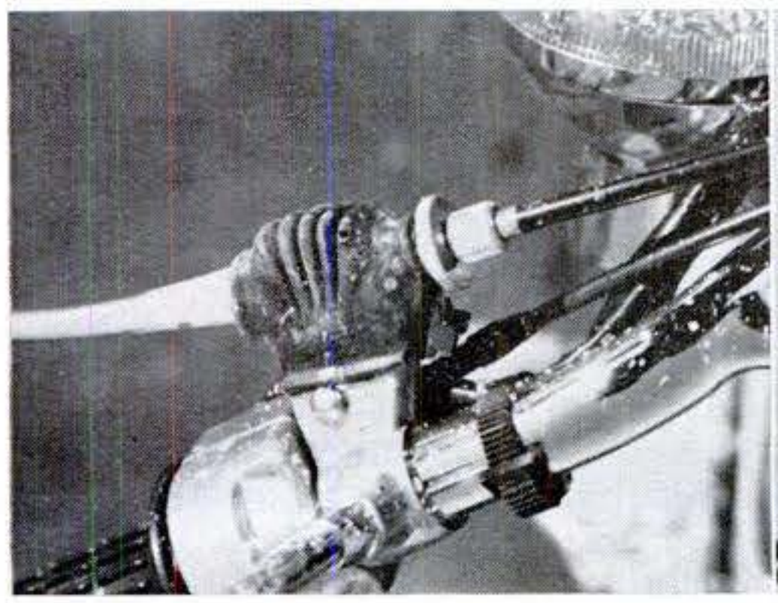
Basically there are two kinds of motorcyclists—on-roaders and off-roaders. Satisfying both with one bike is difficult. The off-roader wants a machine that can climb the steepest hill around. That means an engine with a broad power band—but a transmission that won't permit a very high top speed.

On the other hand, the street rider wants a bike that cruises smoothly along the road at normal highway speeds—meaning an engine with a narrow power band and a transmission that permits a higher top speed, the opposite of a trail bike.

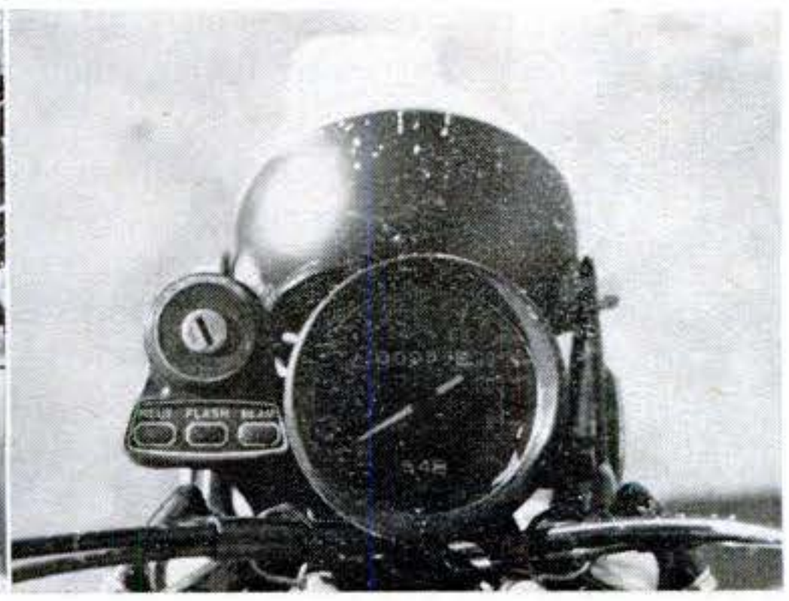
Can a single motorcycle satisfy both riders? Yes—Kawasaki's G-4, with a two-cycle 99cc engine that delivers a fairly broad power band, comes as close as any machine I've seen. The biggest part of the solution, though, is the gearbox—a quick-change dual-range transmission with five speeds in high and five in low. In low range you can climb just about any hill. In high, you're ready for the highway.

Handling? Superb—on the road or off. I rode the bike for three four-hour periods—woods and road—covering some of the slickest, muddiest terrain I could find. Once, I crossed a flooded creek, completely submerging the engine. It never faltered. My only complaint: The footpegs tend to bend down under really severe off-road riding.

Overall, I think this is one of the best little street/trail machines you're likely to climb aboard. PS



To keep out unwanted dirt, the clutch and front brake-lever joints are enclosed by a rubber cover. The covers do a good job, even when traveling through heavy mud.



Three indicator lights beneath the easy-to-reach ignition switch provide info about transmission, turn signals, and headlight. Speedometer includes a trip meter.

KAWASAKI G-4 SPECS

Engine type	2-cycle
Horsepower	not available
Displacement	99cc
Bore & stroke	49.5 x 51.8mm
Ignition system	magneto
Top speed	66 mph
Climbing ability	high range—29° low range—40°
Transmission	5 speed, dual range
Gear ratios	1st—2.92:1 2nd—1.77:1 3rd—1.30:1 4th—1.09:1 5th—0.96:1
Final reduction ratio	2.80 (15/42)
Overall drive ratio	9.46:1
Front suspension	telescopic fork
Rear suspension	5-way adj. shocks
Wheelbase	50 in.
Weight	198 lbs.
Ground clearance	10 in.
Price	$508

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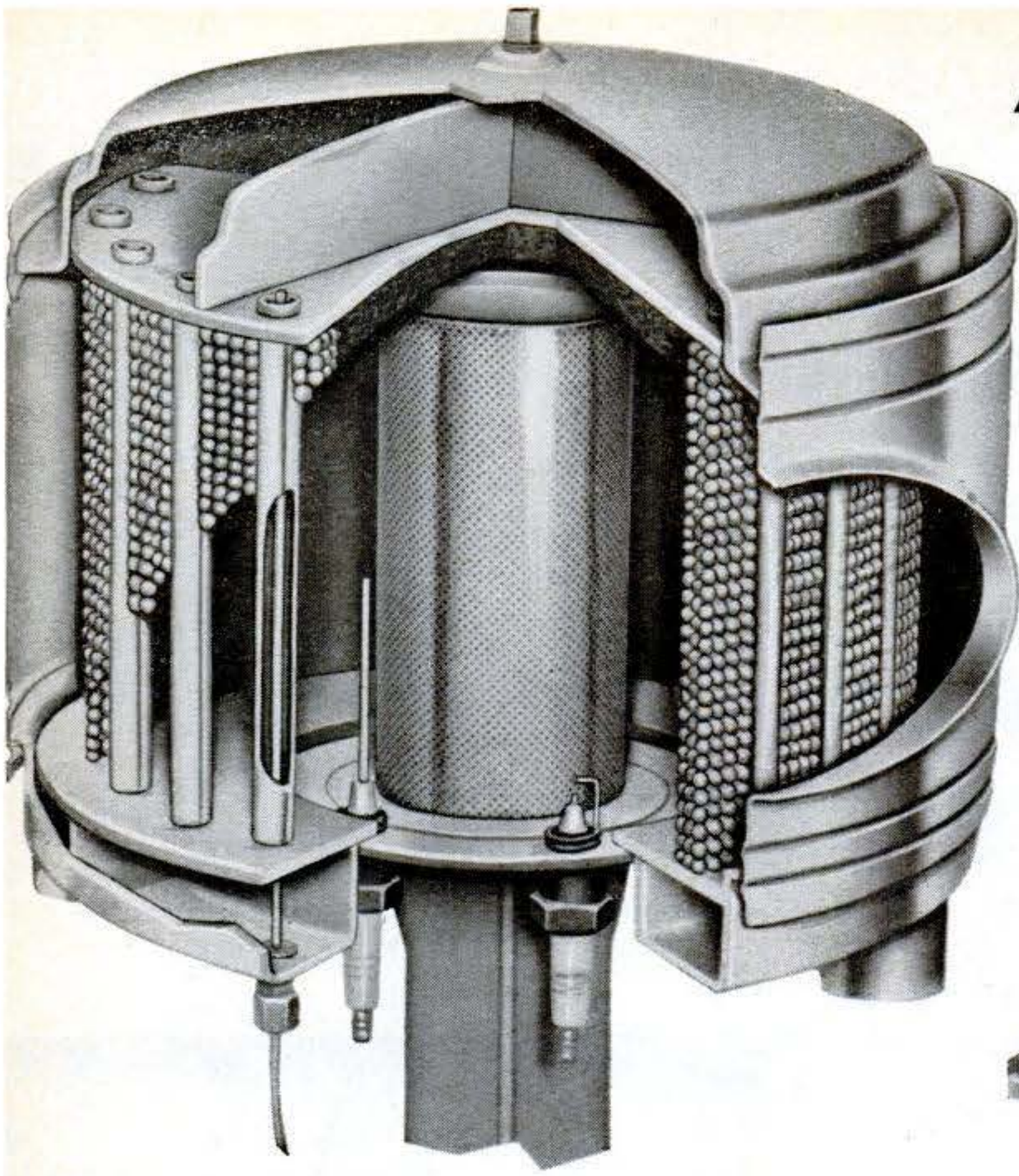
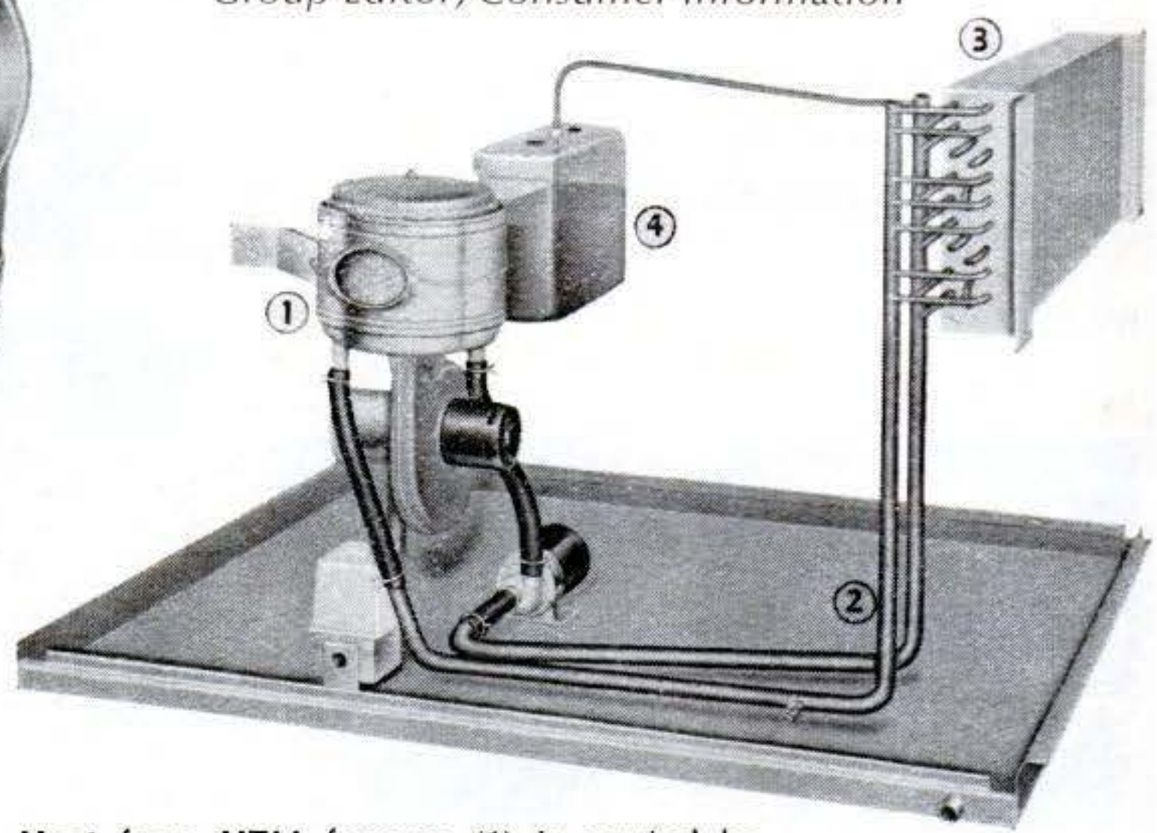


A Furnace the Size of a Soccer Ball

They designed the HTM to carry off heat from a missile-borne radar tube. Now it can heat your house

By EVERETT H. ORTNER
Group Editor, Consumer Information



Amana Heat Transfer Module consists of compact burner set in a matrix of thousands of fused steel balls. Heat is carried off by a liquid (ethylene glycol and water), flowing through steel tubing embedded in the matrix. A spark plug ignites the fuel.

Heat from HTM furnace (1) is carried by liquid through tubing (2) to coil (3), and then "blown" off into house duct. Expansion tank (4) holds overflow of liquid.

Up and over, or just easing through brush, sporty Cobra with Tecumseh two-stroker handles neatly; it fits on narrow bike trails.

Skis mount quickly on Cobra. Maker says it steers better than snowmobile; wide tires give it plenty of traction and go.

The Lean and Lively Cobra

Gutsy enough to crest the toughest hill, and lean enough to slink down narrow trails, a new sport vehicle, the Shelton Cobra 817, weighs only 150 pounds. I particularly liked the asymmetric Comet torque converter that comes in at low engine speed and lets you open the throttle gradually to thread through tight spots without leaping or jerking. Shelton claims a 4:1 ratio on their drive, and my trials showed it matched by plenty of low-end torque from a 133cc, two-stroke, six-hp Tecumseh.

Examination of the structure reveals an extremely rugged, heli-arc-welded tubular-steel frame, ball-joint steering, husky wheels, and big two-ply tires that can be removed and repaired. The body is a combination of fiberglass and molded acrylic bonded together.

The 34½-inch width lets the Cobra 817 fit any snowmobile or bike trail and load into even a small station wagon. For snow use, two spring-mounted skis slip over the front-axle stubs after the wheels are removed.

The basic Cobra sells for $495—or $425 in kit form. Extra-cost options include alternator and lights ($30) plus skis, windshield, and different drive sprockets. Shelton Industries, 10907 Hidden Valley Dr., Cedarburg, Wis. 53012.—*E. F. Lindsley*

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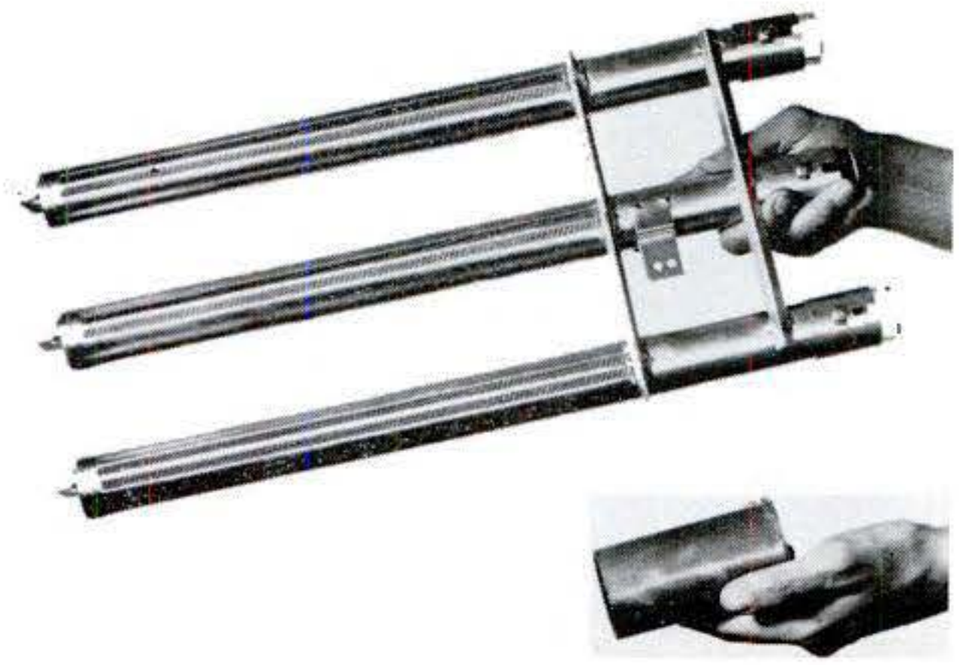
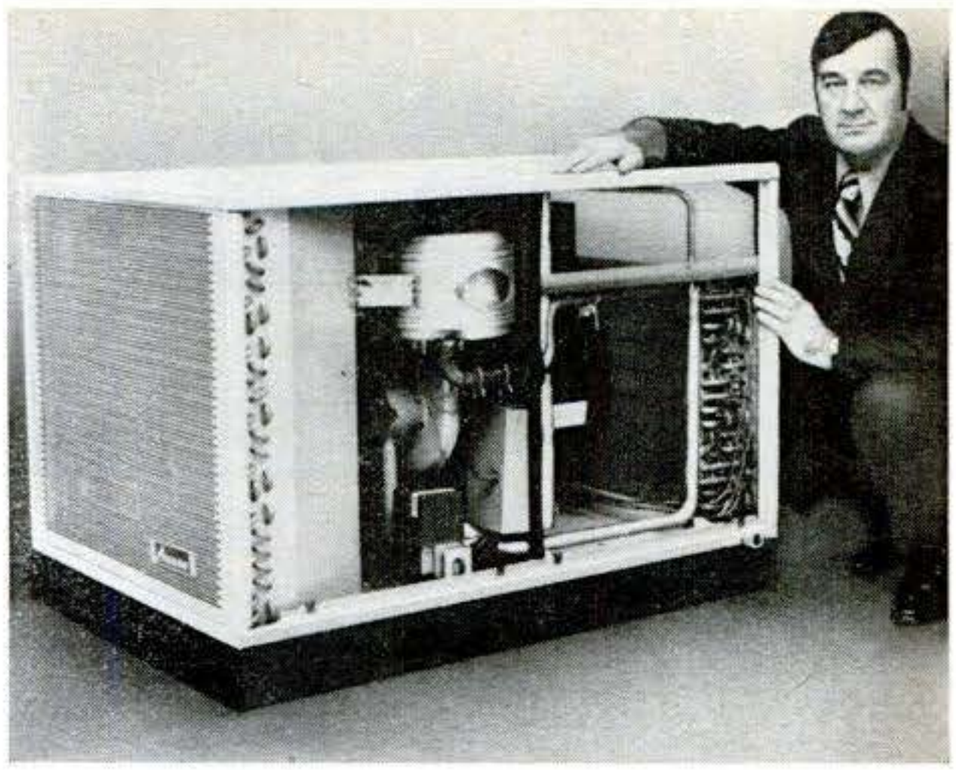


Stainless-steel burner of HTM furnace (bottom, left) is shown compared with conventional gas burner. It's designed to burn natural gas, but converts easily to LP.



Combined system—air conditioner and HTM, visible in center—is designed for outside of house, on roof, or in yard. Maker: Amana Refrigeration, Amana, Iowa 52203.

You can hold this furnace in your hand. Its burner is the size of a water glass. It's so small that it nestles easily in an air-conditioning unit, which then becomes a heating/cooling system for your home.

The little furnace—Amana calls it a Heat Transfer Module, or HTM—was born in the laboratories of Amana's parent company, Raytheon. (First details were revealed in POPULAR SCIENCE in Sept. '72.) Engineers there were looking for a way to quick-cool high-power radar tubes. They came up with the HTM. Then they had another thought. Why could it not also transfer heat from other heat sources—like a gas burner?

And so came the HTM furnace. Its heart is a stainless-steel burner that produces thousands of tiny, hot flames. Surrounding the burner is a matrix of steel balls. Steel tubing in this matrix carries a liquid—ethylene glycol (just like the coolant in your car) and water. The heated gases created by the flames pass through the matrix with a high turbulence that rapidly transfers the heat to the liquid.

The air-conditioning plumbing then takes over. The heated liquid is pumped through a coil, where a fan blows off the heat into the warm-air duct of your house.

Amana claims a 10-percent fuel saving on the basis of three factors: 1) more efficient burning of the fuel; 2) two-stage operation—on mild winter days, the HTM runs at two-thirds capacity (80,000 Btu), and goes to full capacity (120,000 Btu) only on cold days; 3) there's no pilot light—the unit uses spark-plug ignition.

Eight models are available, all with the 120,000-Btu furnace. Only the cooling capacities vary, from 24,000 to 60,000 Btu. What do they cost? With a 36,000-Btu unit, Amana estimates $1400 to $1800. PS

Mini-Camper on a Mini-Pickup

Designed to fit on Toyota chassis, this new Chinook camper has a low profile (above) for highway riding, but pops its top (right) when you're parked at a campground.

Compact galley in camper has two-burner butane stove, sink, and ice chest. Dinette at left converts into a double bed. Headroom is over six feet.

Now, for the increasingly popular mini-pickups, there's a new kind of pop-top camper. Made by Chinook Mobilodge, it's custom-built to fit on the chassis of Toyota's small (110-in.-wheelbase) pickup. The chassis has been beefed up with heavy-duty suspension, 2½-in.-wider rear axle, and bigger rear tires (8.25 x 14). The front wheels have 7.00 x 14 tires.

The camper comes with ice chest, two-burner butane stove, sink, and five-gallon water tank. It will sleep two adults—the dinette converts to a double bed—and two kids as well.

The rig is 200 inches long overall, 76 inches wide, and is powered by a four-cylinder, 120-cu.-in. overhead-cam engine. It will be sold exclusively through Toyota dealers, and will be test-marketed early this year in California, Arizona, and Nevada.

Camper interior is neatly furnished. There are under-counter cabinets for storage. Floor is carpeted and there are big windows for full view of the landscape.

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What's New

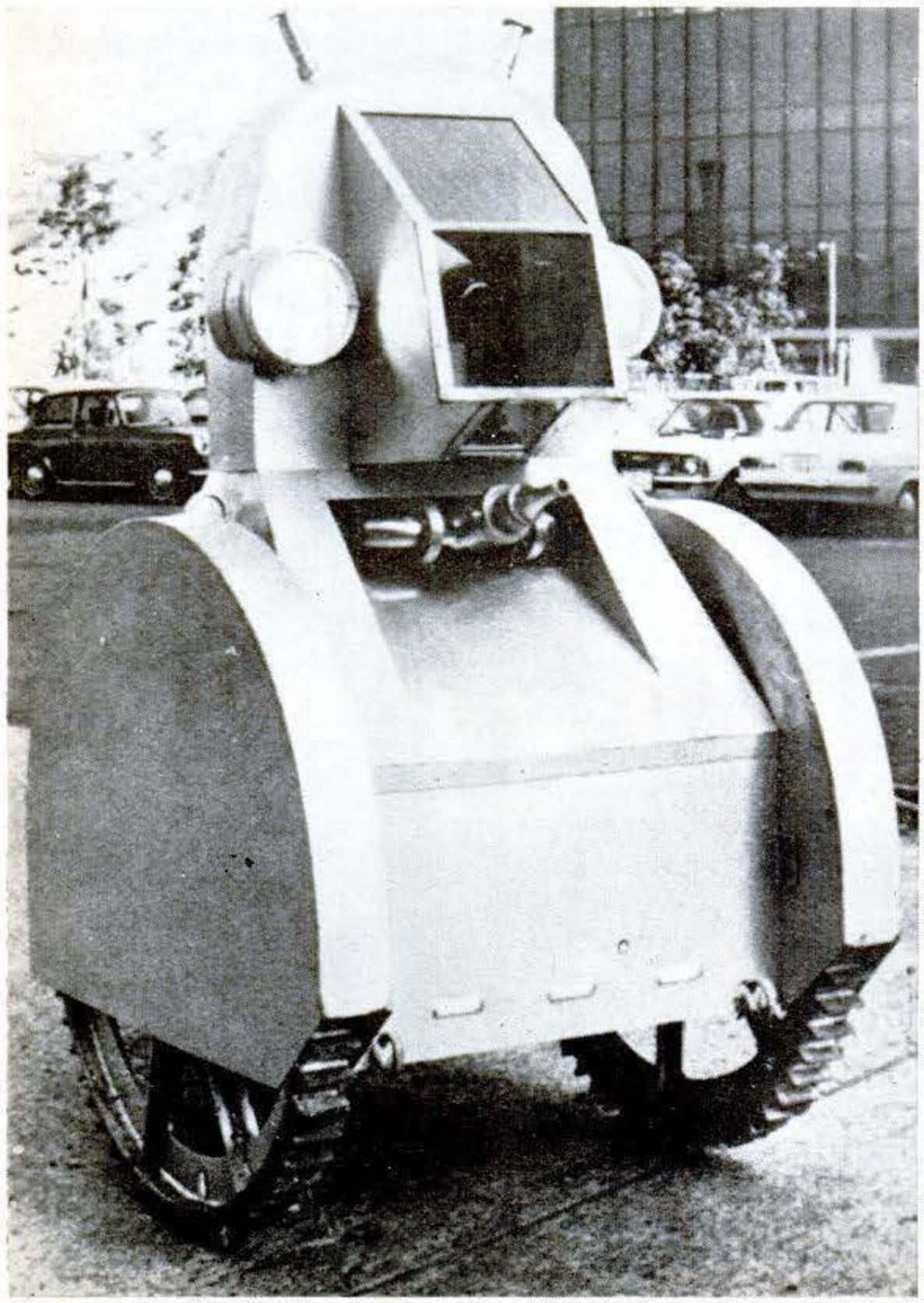
A PICTURE ROUNDUP OF NEW PRODUCTS AND DEVELOPMENTS

Speed reader

Pity the poor police departments that can't afford a $2000 radar unit to catch speeders? Not now! The Broussard indicator, designed by a NASA engineer, would do the same thing for $200. It's an "elapsed-time speed computer" that calculates speed as a vehicle passes two markers.

Snow truck

The snow-going equivalent of a half-ton pickup truck, the Snotruk weighs a half-ton, totes a half-ton, and can be carried in a half-ton pickup. Built by Nortrac Mfg. (Arnprior, Ont.) as a cargo carrier, it'll do 21 mph and crawl up a 60-percent grade.



Fire eater

Heat doesn't bother one member of the Yokohama Fire Brigade: their Robot Fireman, who can advance toward a fire at 10 miles an hour and even walk up stairs to extinguish the flames. He stands about six feet tall, weighs about 1300 pounds, and gets radio orders.

Bump seat

How much of a bump on the road reaches a passenger in a car? This "bump seat" at Penn State University gives the answer. Combined with a Profilometer that measures road roughness, it enables engineers to trace energy flow from the "road to the passenger's head."

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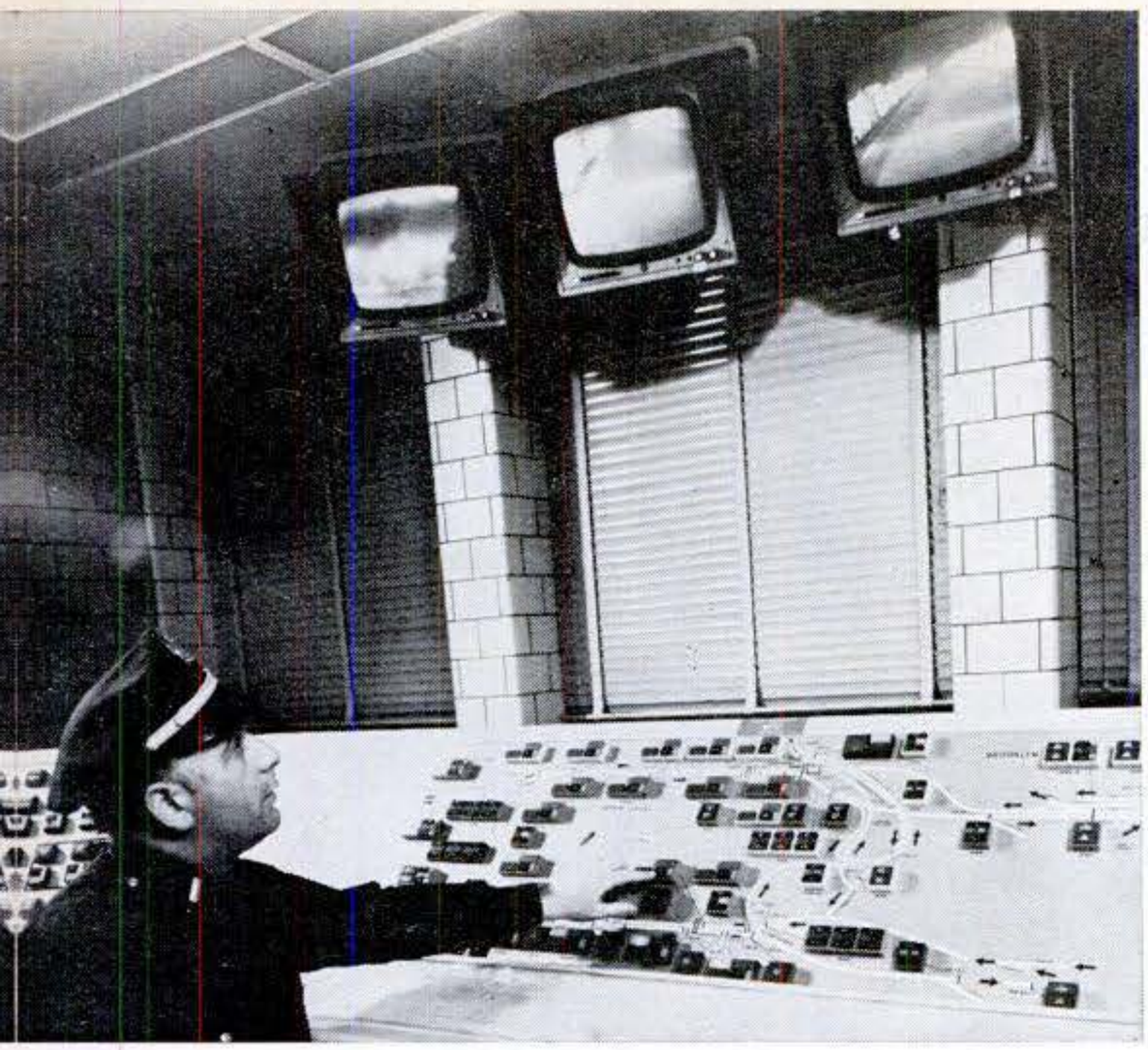
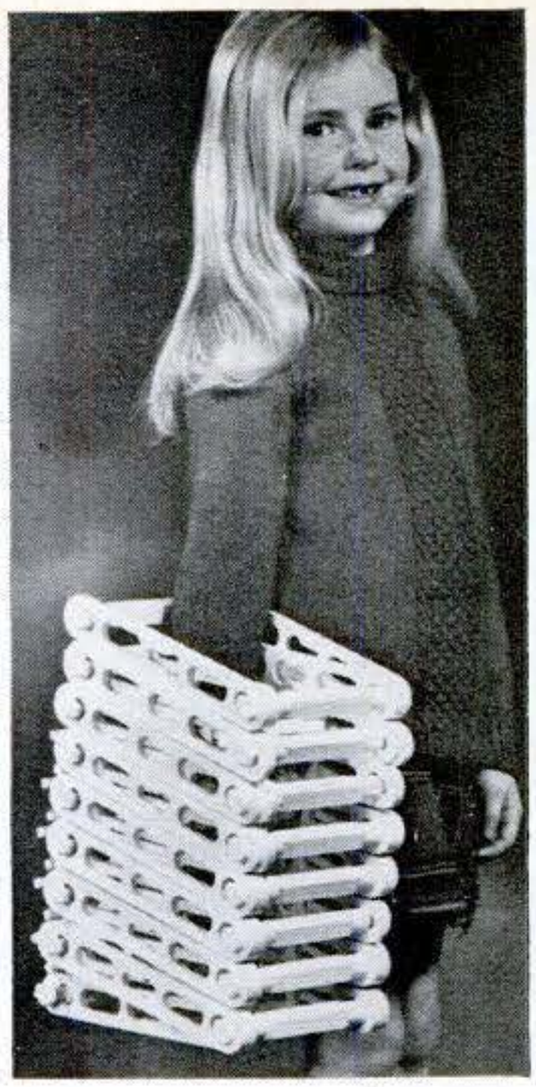


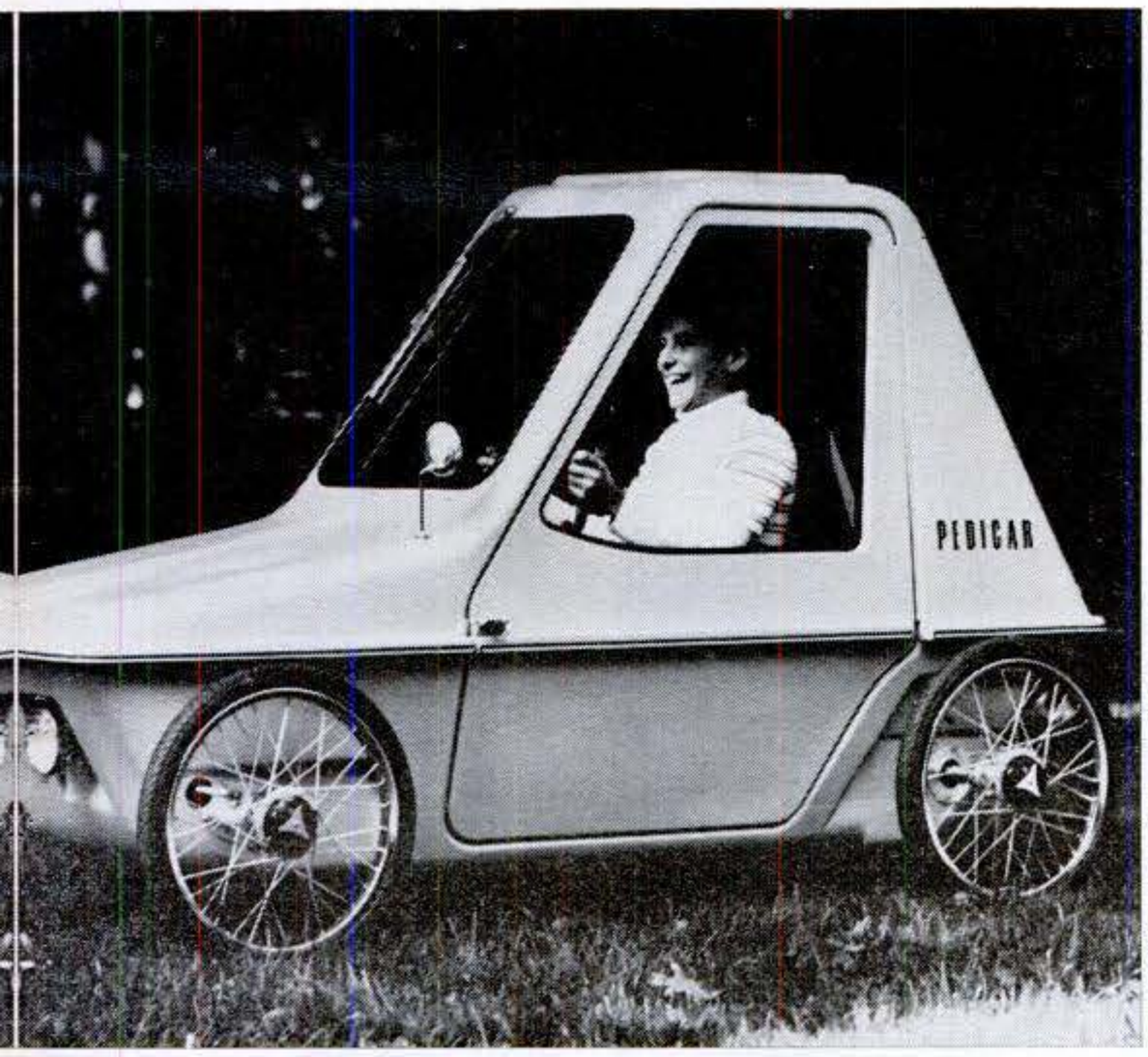
For bridge traffic: a speedy signal-change system

Traffic officials can react immediately to changing weather or traffic conditions on New York's Verrazano-Narrows Bridge with this automatic lane-control system. Four closed-circuit TV cameras in the bridge command room monitor traffic and spot motorists in trouble. Temperature gauges warn of icy roadways. By pressing the appropriate buttons on his control panel, this police lieutenant can redirect traffic flow at once. The system was developed by Cutler-Hammer, Inc.



Fold-up ladder

Hook this collapsible nylon ladder over a window bracket and you have a fire escape. Spacers hold it from the wall. Or use it on a boat. A 15-foot length weighs six pounds. The English-made ladder is distributed in the U.S. by Foldladder Co., Box 187C, Midland Park, N.J. 07432.

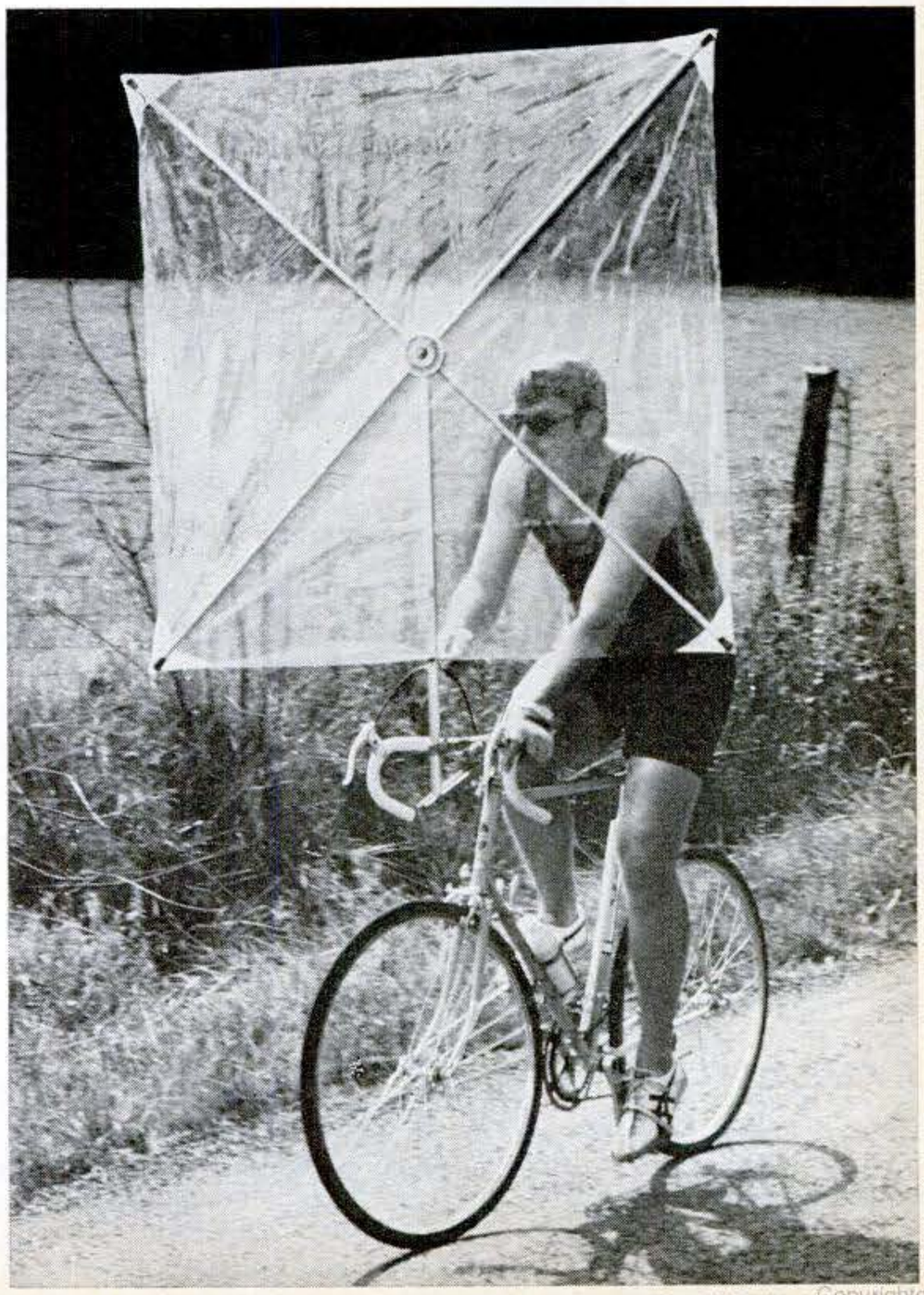


Charley-horse power

No pollution with the Pedicar—you're the engine. The enclosed pedal vehicle has five forward gears, plus reverse and neutral, and can climb grades, says the maker, Environmental Tran-Sport, up to 20 percent. The body is plastic; and headlight, wiper, seat belt, and bucket seat are standard.

Bike sail

Mount a four-foot-square sail on your bike, grab the tiller, and you're off with the wind—at speeds of 20 and more miles an hour, claims its maker. The mast is aluminum, the sail 12-gauge plastic, the price $19.99 from Viking Bicycle Sail Co., 133 Harding Blvd., Oregon City, Ore. 97045.



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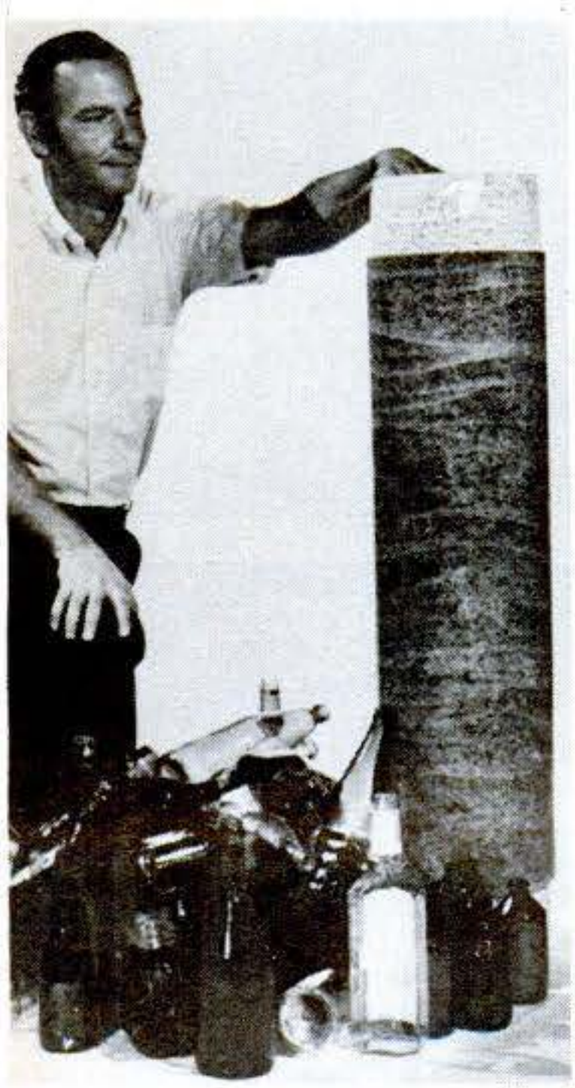
What's New

Turnaround

What will that space-shuttle orbiter look like after a flight? Like this artist's depiction, according to North American Rockwell, which will be making the craft. American Airlines will maintain and service the ships, with the object of a two-week turnaround between flights.



Beer-bottle pipe

Recipe: Mix 118 crushed beer bottles (including caps and labels) with liquid plastic. Result: this 40-inch length of eight-inch pipe, now installed in the Huntington, N.Y., sewer system. The pipe can be machined with standard tools. Brookhaven National Laboratory developed the process.

For Italians: one Fiat for today, one for tomorrow

The old Fiat 500—the car that has filled Italy's streets—is on its way out, and here's its successor (above, left): the Fiat 126. It has modern chunky styling, a shade more interior space, and an air-cooled 594cc twin in the rear that puts out 23 hp for a top speed of 65 mph. What will the city car of the future look like? At right is Fiat's answer: an egg-shaped vehicle with a design suitable for different engine layouts; thick energy-absorbing expanded-plastic bumpers that extend along the sides in protective ridges; and window glass all around for full-circle visibility.

Dynamite sniffer

Dynamite around? This British Royal Engineers sniffer sucks in fumes through its nozzle and passes them back to cylinders of argon gas on the operator's back. If there's dynamite or gelignite nearby, the device emits an audible tone.

Molded cart

Say good-bye to the old steel supermarket cart, say the makers of this plastic job, Wahl Associates. It's lighter, cheaper, can be molded in any color, and—with a store's name on it in big letters—may even reduce the present annual theft rate for carts of 25 percent.

Contact thermometer

Touch the probe of this electronic thermometer to any point of the body, and in seven seconds you get a temperature reading. The device, demonstrated at a medical congress in Berlin, costs about $6 to manufacture.

Noise filter

Disturbing—and dangerous—high-frequency sounds are filtered out by the Sonic Ear-Valv, says the maker, while the low frequencies needed for understanding speech get through. They're $4.95 a set. Maker is Sigma Engineering, 11320 Burbank Blvd., No. Hollywood, Calif. 91601.

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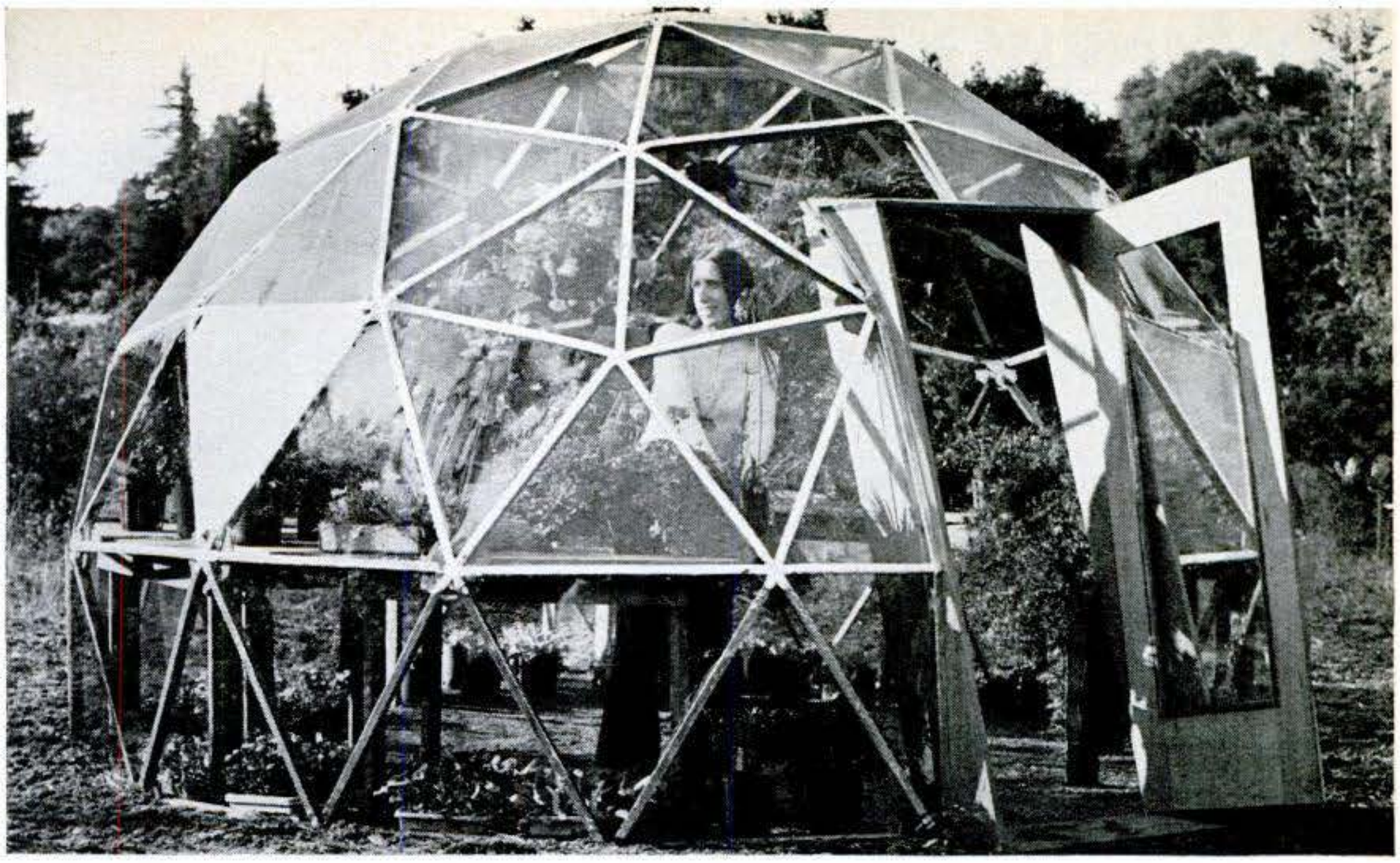
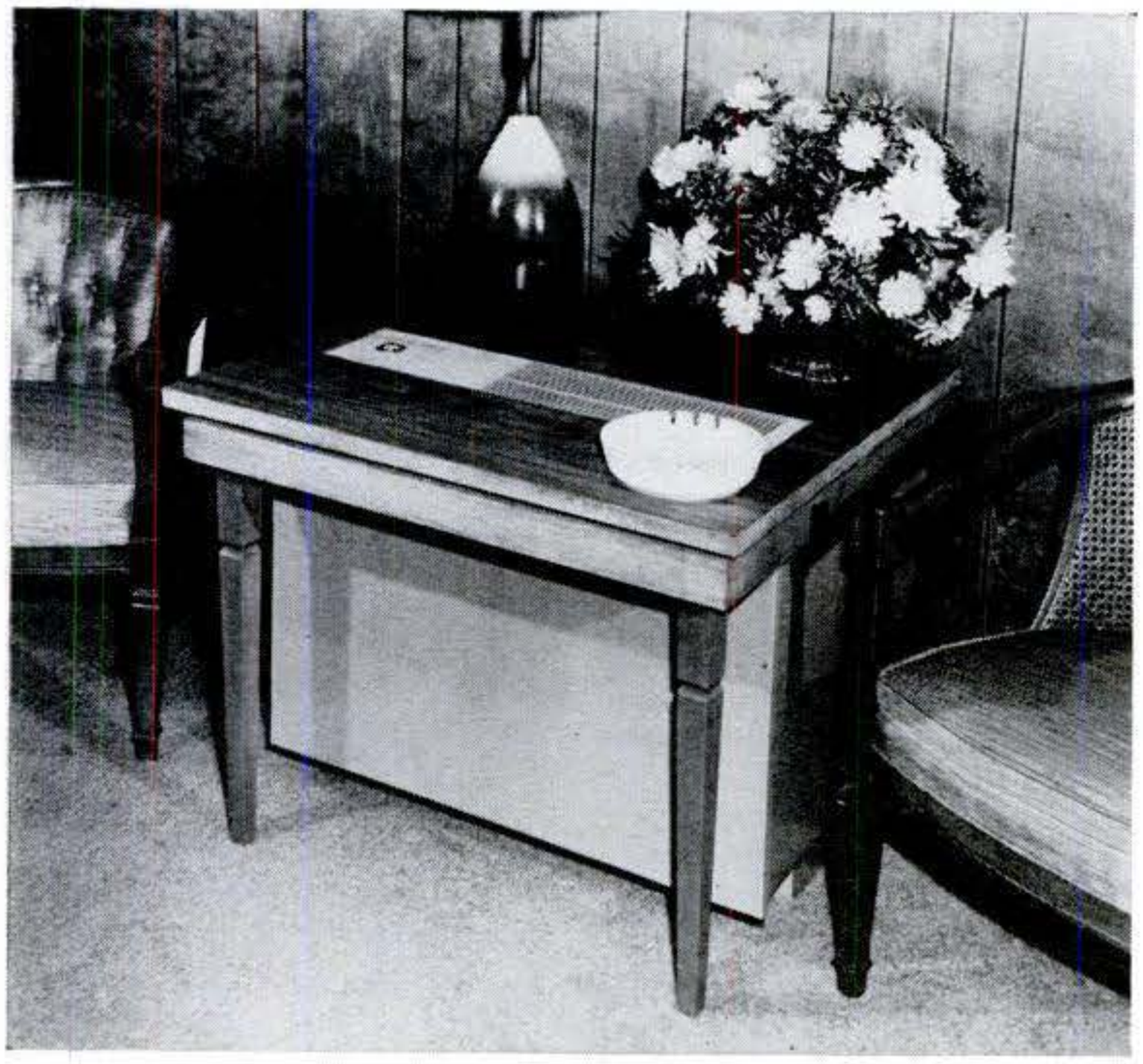
What's New
IN HOME IMPROVEMENT



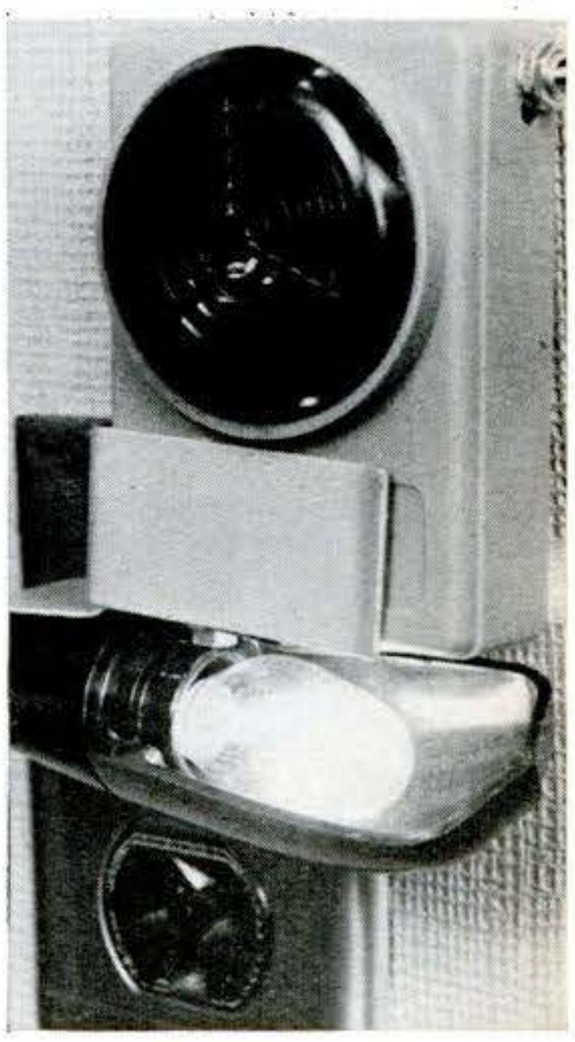
Greenhouse dome

It comes in a kit—here's what you get. A 14-foot diameter; 12-mil optically clear vinyl covering; all-redwood framing; bolt-together, color-coded, one-day assembly. No foundation is necessary, so it's easy to move. Redwood Domes, Aptos Calif. 95003, makes it. Benches, heaters, etc., are available.



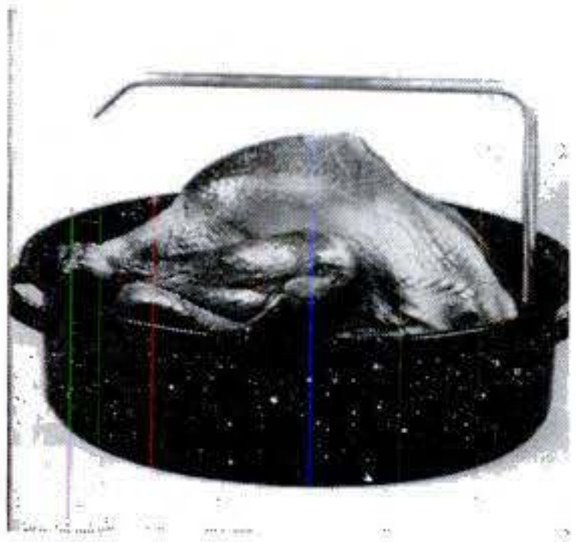
Blackout alarm

Looking for protection against power blackouts? This alarm gives you the bad news whenever the juice goes off (a delay prevents activation by momentary power cuts). There's a built-in night light, too. Riton Mfg., 7839 12th Ave. S., Minneapolis 55420, makes it. Price? $14.95.



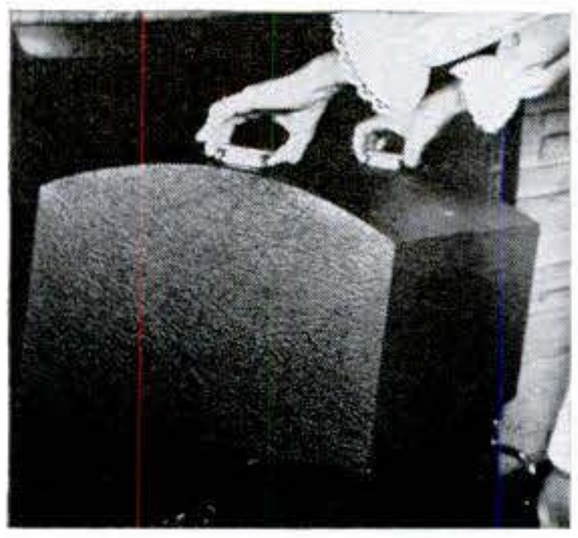
Cool space saver

An air conditioner that won't steal floor or window space—that's the Cool Table, a table top, two legs, and an air conditioner that hides under the table. Three models span a Btu range from 8500 to 15,500. Friedrich Refrigerators, 4200 N. PanAm Expwy., San Antonio, Tex. 78295.



Chef maker

Too busy to baste? Let Baste-O-Matic do the job. You slip it into the roasting pan; it does the rest—cycling natural juices over the meat to prevent drying. Works with fowl, pork, beef—anything you roast. Price? $3.30 from Lewis & Assoc., 510 Highway 131E, Clarksville, Ind. 47130.



Fireplace snuffer

Bedtime comes—how do you put out the roaring blaze in your fireplace? With Snuf-It, a giant metal "candle snuffer" for the fireplace. It's $16.15 from REM Industries, 204 Simms Bldg., Dayton, Ohio 45402. Specify grate size and fireplace width and depth when ordering.

Easy framing

Just place glass, print, and backing into the frame and—zip—lock them together with a special rubber cord. No nails, staples, or glue are required. Zip-In frames are from MacCluney Sales, Rte. 1, Ashland City, Tenn. 37015.

Way-out walls

Would you believe a fabric wall covering you apply with a roller? It's for real. Add water to a mixture of fabric fibers and glue powder. Knead, and roll it on. It dries in about two days. A package covers about 30 sq. ft. Dream Wall Sales, 1397 Commercial Dr., Vancouver, B.C.

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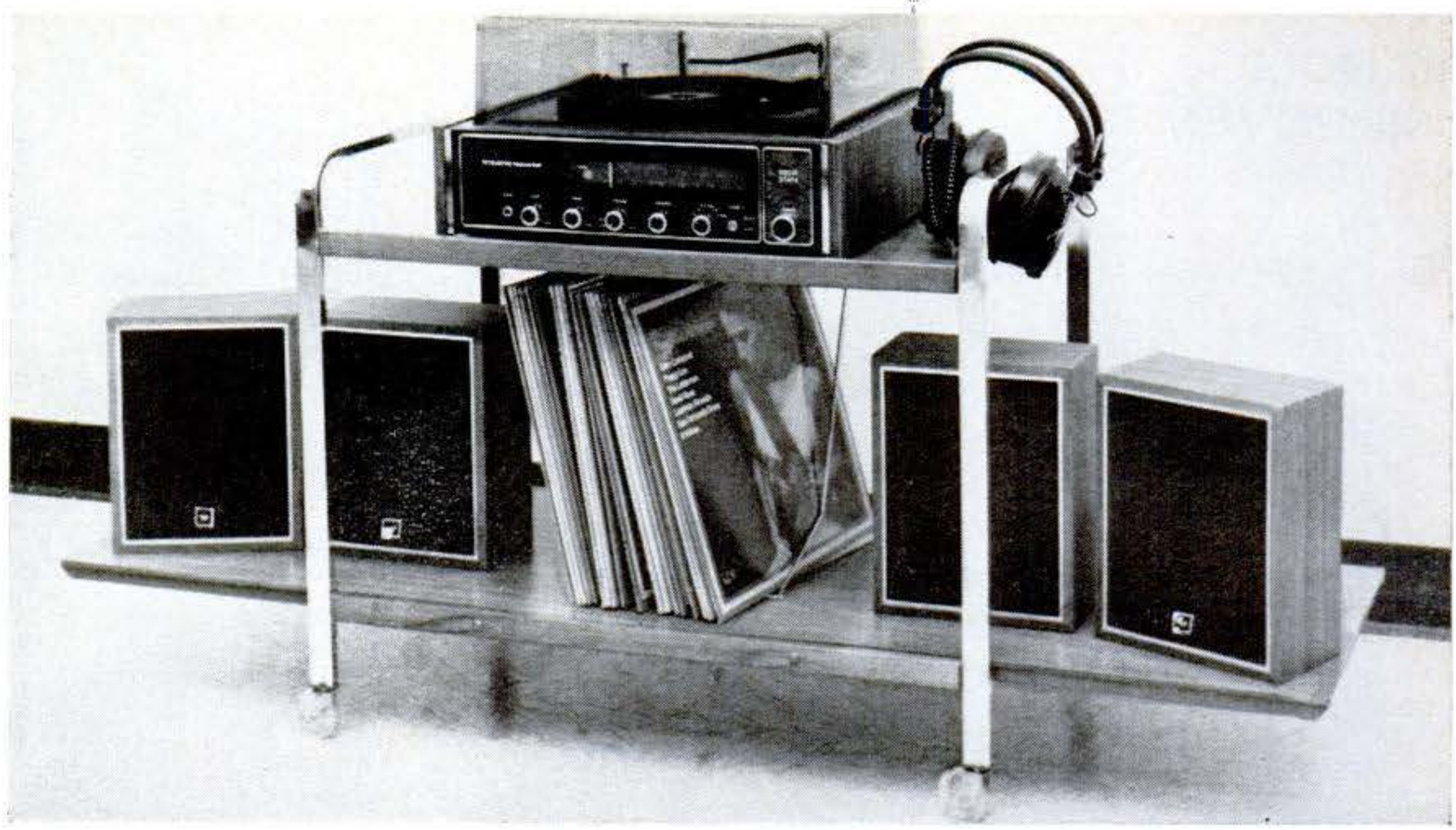
What's New IN ELECTRONICS



Rolling sound system

A take-along sound system? Not exactly, but close. This rolling sound system from Teledyne Packard Bell comes complete with AM/FM tuner/amplifier, record changer, four speakers, stereo headphones, and the walnut-finished wheeled stand. It's $179.95.

Cartridge deck

Add this Wollensak 8060 eight-track-cartridge deck to your stereo system and you're all set to reproduce most forms of two- and four-channel sound. It records conventional stereo and matrixed discs, and plays prerecorded discrete four-channel tapes. Price: $199.95.

Mini-recorder

A built-in condenser mike and an automatic level control for conference recording are features of the Crown CTR-381 cassette recorder. A three-digit counter keeps an eye on tape, and a meter checks record level/battery condition. It's $89.95.

UHF-VHF scanner

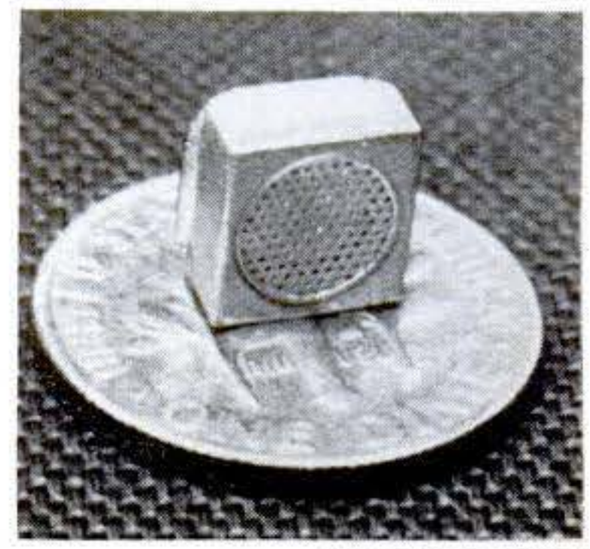
The Scan Monitor from Pace does just that—scans 16 frequencies, eight at a time, on the 25-50-MHz, 140-174-MHz, and 450-470-MHz bands. Switches on front and rear select frequency and scan mode. Crystals required. $199.95 from Pace Communications, Harbor City, Calif. 90710.

Fish spotter

Somethin's fishy? Only if you hear the alarm. The Heathkit Fish Spotter beeps if one or more fish pass within a range you've selected. The unit also doubles as a dual-range depth finder for 0-60 or 0-240 feet. $99.95 from Heath, Benton Harbor, Mich. 49022.

Small talk

That isn't just an electret condenser microphone resting on a dime at right—it's also the amplifier. An FET amp allows the mike to be plugged into a standard mike input on a recorder. $13.50 from Electronic Enterprises, 3305 Pestana Way, Livermore, Calif. 94550.



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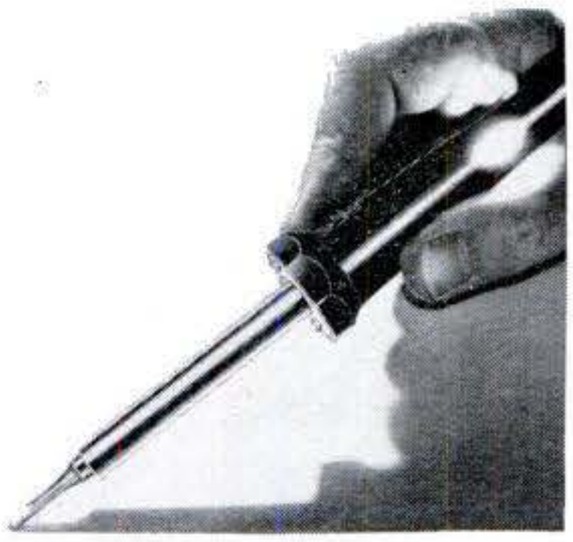
What's New IN TOOLS

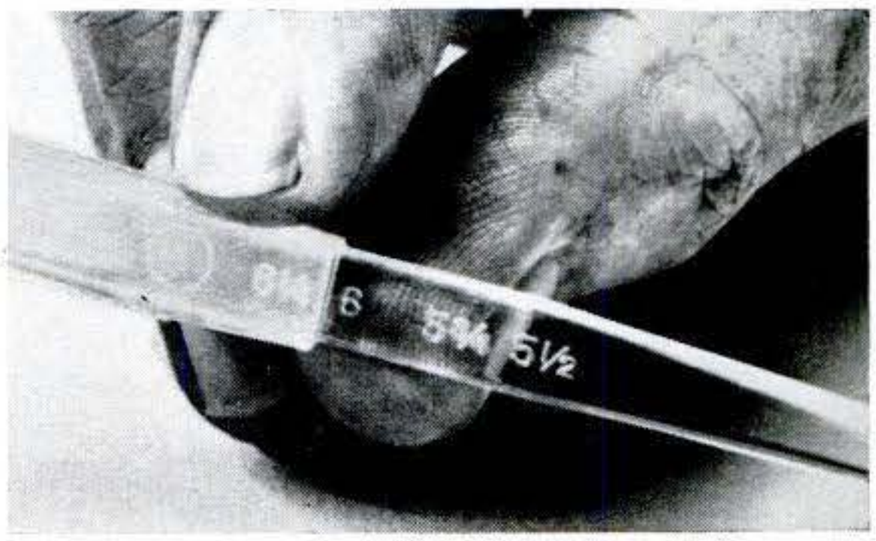
Gentle wrench

Ordinary pipe wrenches will chew up plastic pipe. Solution? The new strap wrench from Ridge Tool Co. Its urethane-coated nylon strap gives you the grip you need without leaving a mark. Quick adjustment lets it take on pipe from 1/8-inch stuff up to the five-inch stuff.



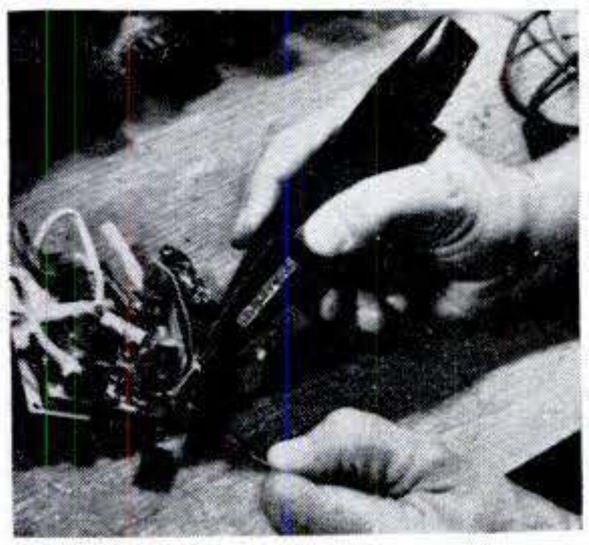
Electronics iron

Electronics soldering is delicate work and it calls for a special iron. The new model 540 from Endeco fills the bill. It has a built-in light, 20-40-watt operation, three-way switch, and a weight of just 4½ ounces. An attachment converts it to a desoldering iron. $8 with one tip.



Stretch glasses

Telescoping temples mean these safety glasses fit—no matter how your head is put together. MSA, 201 N. Braddock Ave., Pittsburgh 15208, makes them in a variety of styles with spatular or cable earpieces, with or without side-shields. Colors? Black, smoke, and transparent pink.



Locking handle

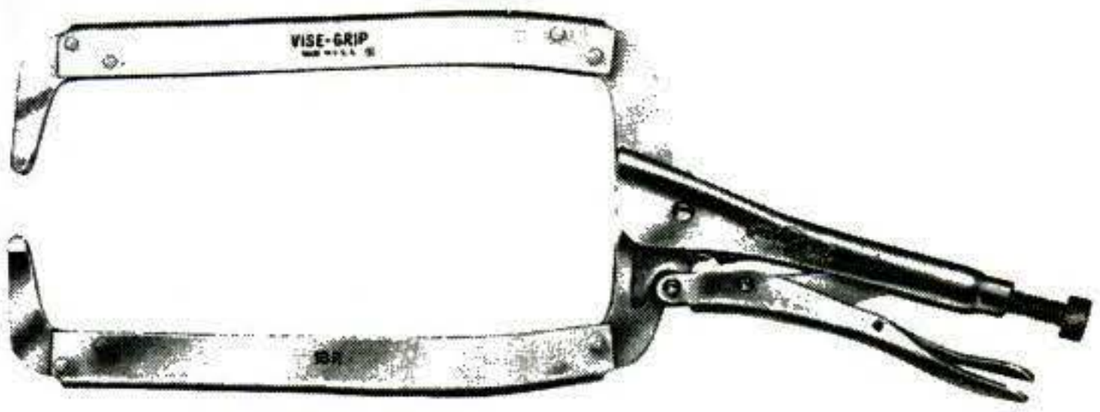
Here's a handy tool for your toolbox—a handle that'll grip hacksaw blades, bits, reamers, files, scrapers, and other hard-to-manage items. The Speedcor handle holds them all securely. It's made by Speed Corp., Box 3437, Portland, Ore. 97208.

Battery iron

You can't beat a cordless for soldering convenience. And here's a new cordless with a new low price—around $23 with charger, tip, and ni-cad battery. Specs? 700-degree working temp, about 100 joints per charge. Wahl Clipper Corp. Iso-Tip is sold at tool stores.

Big-bite clamp

Here's a giant C clamp with the operating speed and powerful squeeze of Vise-Grip pliers. And no wonder, it's made by Petersen Mfg.—the makers of Vise-Grip. It has a big 10-inch reach and will open to seven inches.



Two-piece vise

Two-part construction gives this little vise extra versatility. You can remove vise and workpiece from the swivel base for inspection or to use as a hand-held work holder. The jaws open to an inch and a half. Price? $11.95 from the Tool Crib, 17 Thayer Circle, Randolph, Mass. 02368.

Blaster

Remove paint or rust, etch glass, weather wood, clean castings—this little sand blaster does it all. Hooks to standard air chuck. No air supply? Make a deal to use your local service station's air line. The gun's $32 from Brookstone, Brookstone Bldg., Peterborough, N.H. 03458.

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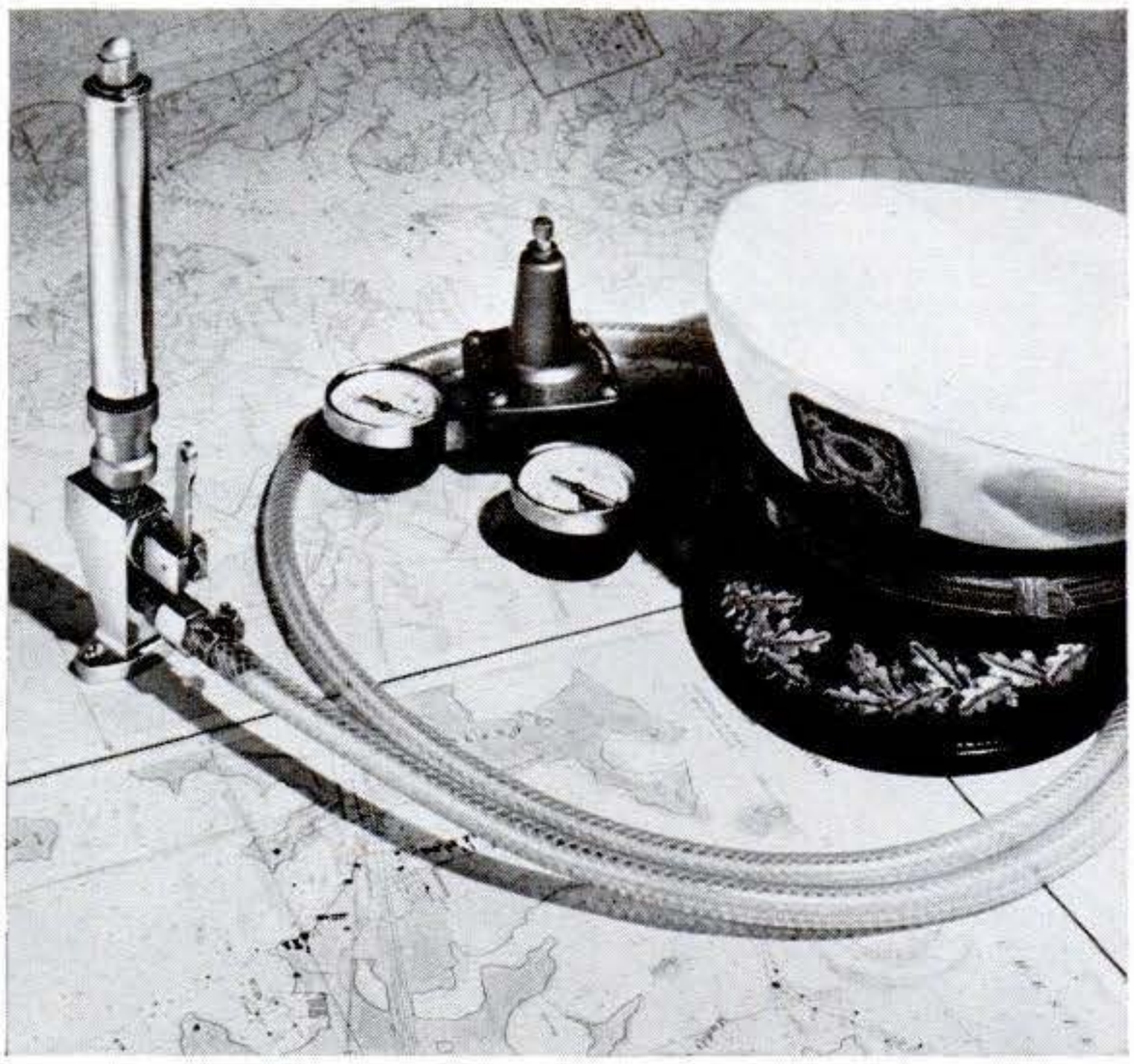
What's New
IN BOATING

Electric boat

Now there's a quiet, pollution-free electric boat. Powered by two heavy-duty marine batteries, the 18-foot Electra's inboard will drive the boat for 30 miles at five mph. Need more juice? Just plug 'er into a 115-volt outlet. $4500 from Bronson Boat Co., Port Salerno, Fla.

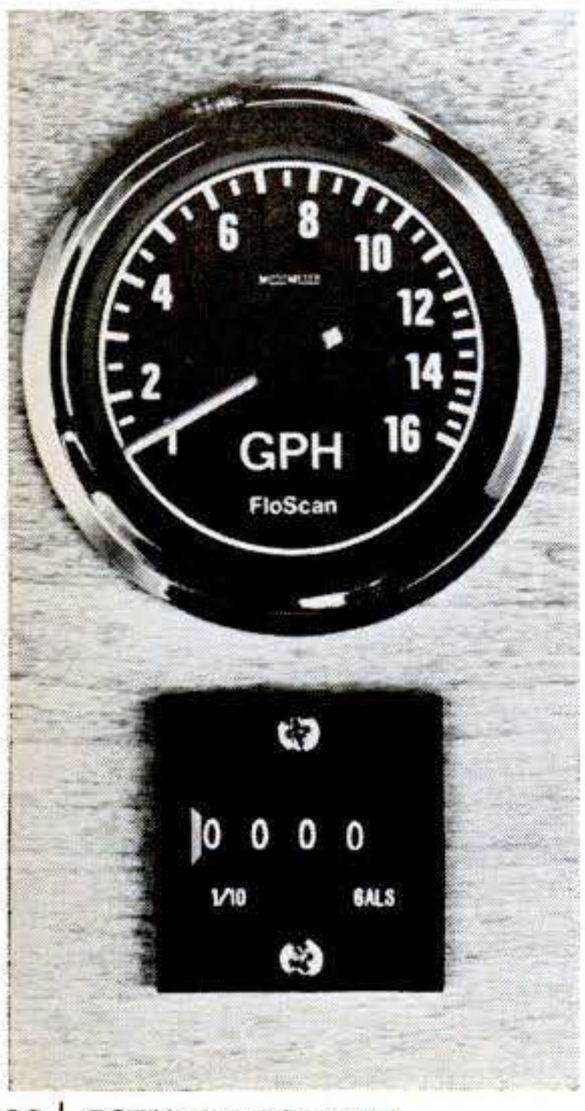


Day sailer

Sunflower has a new sister—the Mayflower, a lateen-rigged 11½-foot cartopper. You can hoist an 82-square-foot sail or mount a five-horse outboard on her stern. She seats four (530-pound capacity), weighs 80 pounds, costs $449 ready to sail. Snark Products, 1580 Lemoine Ave., Fort Lee, N.J. 07024.

Steam whistle

Want a little nostalgia on your boat? Nauti-Call's a steam whistle that sounds like those on the old paddlewheelers. Trick to the sound: a specially tuned resonator. It comes with CO_2 regulator, couplings, 10-foot hose. $49.95 from Bastian-Blessing, 4201 W. Peterson Ave., Chicago 60646.

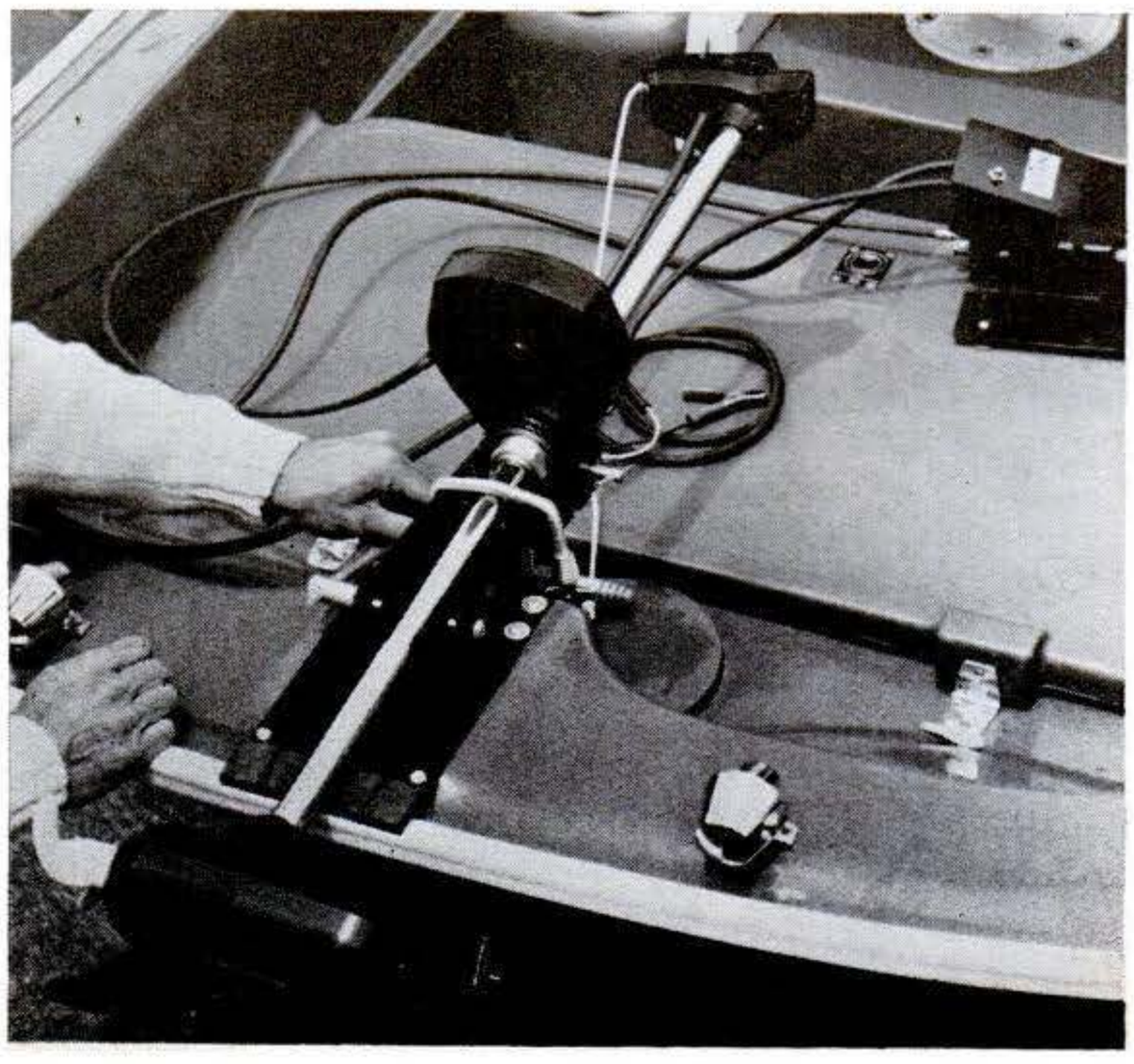


Super gas gauge

Maximize cruise economy with Totalizer—two instruments that display fuel remaining (digital readout, bottom) and gallons-per-hour flow. They'll work with singles and twins, and some diesels. Cost? $99. Maker is FloScan, 3016 N.E. Blakely St., Seattle 98105.

Trolling motor

Need both hands free for fishing? Take a look at the new Ranger II—an electric motor with foot-pedal steering. Press your toe down to go right; heel to go left. The 37½-inch shaft is capable of 360-degree steering. Weight: 30 pounds. Price: $190. Electra Pal, Box 26952, El Paso, Tex. 79926.



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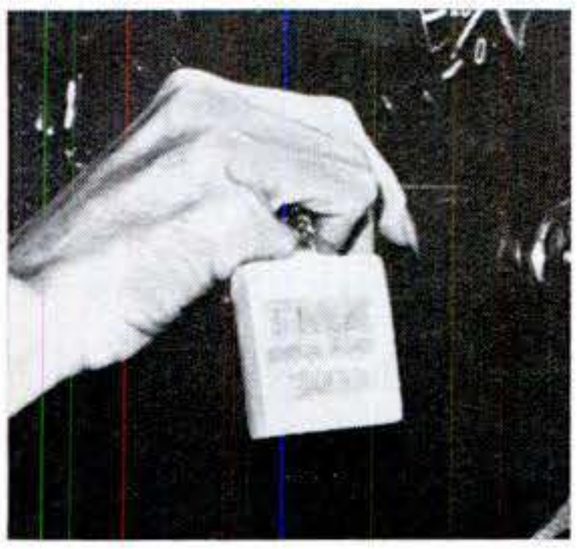
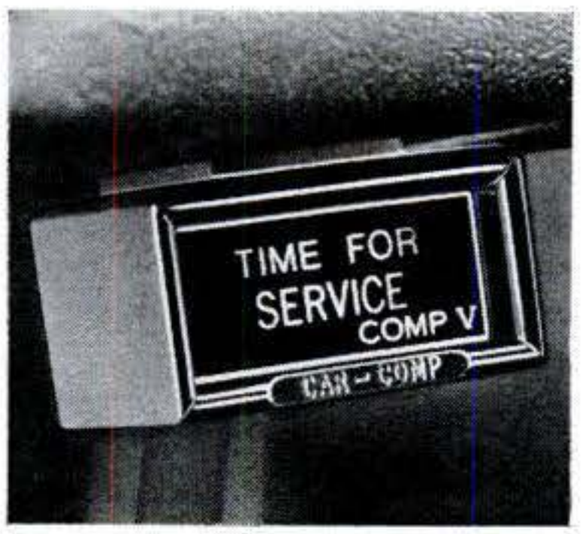
What's New
FOR YOUR CAR



Car decoder

Put a computer in your car and thieves will have a tough time. The car won't start until you insert a matchbook-size transmitter that sends coded information to the data terminal, to release the electrical system. TMX 2000 is $69.95. TMX, 666 Fifth Ave., New York, N.Y., 10019.



Service reminder

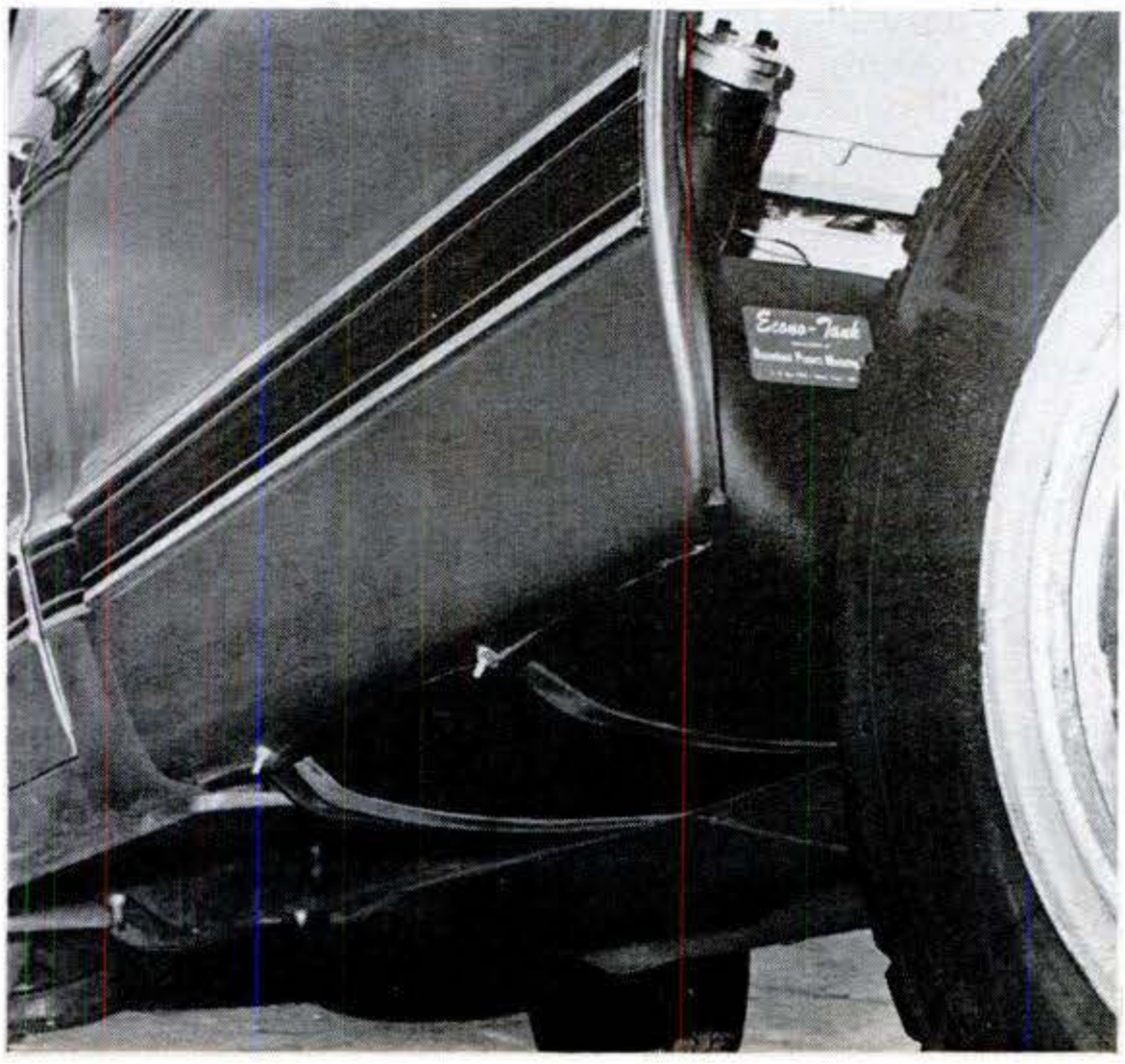
How many hours has your car run since its last servicing? The Car-Comp tells you by lighting up a message on the face of the housing. The unit hooks up to your car's fuse block. Maker: Compuline Corp., 215 Plank Ave., Paoli, Pa. 19301.

Rugged rack

Designed for rugged use on four-wheel-drive vehicles, the Baja luggage rack has been modified now to fit any rec vehicle. It's five feet wide, 5½ long, six inches high; weighs 68 pounds; clamps to your car's rain gutters. Price: $99.50. Con-Ferr Mfg., 300 N. Victory Blvd., Burbank, Calif.

Level rider

No tips, no spills with the Beverage Caddy—it's always on the level. The plastic unit holds a 12-ounce can or cup, collapses for storage, attaches to the underside of your car's dash. It's $2.29 from D. Baker, 2826 Rhoades Rd., San Diego, Calif. 92139.



Accessory tanks

They're stronger than seven-gauge steel and one-fifth the weight, says the maker of Econo-Tanks—new 40-gallon add-on tanks designed to go under the side panels of most long, wide-bed pickups. Recreational Products, Box 7935, Waco, Tex. 76710.

Traction aid

Stuck in the snow? Slip these lightweight steel tracks under your rear tires for instant traction. They weigh 13 ounces, sell for $3.98 a pair from Mellinger Enterprises, Box 705, Redwood City, Calif. 94064.

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Troubleshooting Your Car's

Know what to do when your spark plugs break down too early? You'll learn this and more in our automotive quiz—part two of a series

By RAY HILL

1 Engine performance declines rapidly after tuneup

Because you wanted your car to be in top-notch shape when you left on vacation today, you had it tuned yesterday. This morning as you backed out of your driveway and headed down the road, you weren't disappointed. The car was running fine.

You've covered the first 200 miles with nothing unusual happening. Now you begin to notice that the engine is losing power when you accelerate. Gradually this condition gets worse until the car is reluctant to reach turnpike speeds.

You pull over to a stop at the side of the road and get out your emergency tool box. You remove the fuel filter, thinking it may be clogged. But blowing through it reveals that there's no obstruction.

How about the spark plugs? Could be they weren't gapped properly and are fouling. No—pulling the plugs, you find that they're clean and gapped to spec.

Next you remove the distributor cap and check the new points that were installed yesterday. You find that their mounting screw is tight and they're not pitted or corroded. But when you check the point gap, it's only five thousandths of an inch! Immediately the reason for your problem is clear—the point gap is just too narrow.

You regap the points to 20 thousandths, the spec for your car (it varies, depending on car model). Now the car runs fine.

But the next day, after 200 more miles, the same thing happens again. The point gap has narrowed, and the engine is losing power. Again, checking the mounting screw you find that it's still tight.

What could be wrong?

2 Slow cranking

It's a cold, snowy morning. You hit the starter, and to your dismay the engine turns over slowly, as if the battery were almost dead. But the car finally starts, and you drive off. That evening it happens again—slow cranking. Finally, when you've about given up, the car starts.

When you get home you check the battery with your hydrometer. As you had suspected, it needs charging. The hydrometer reads 1.170, far below the 1.260-or-above reading that would indicate a full charge. Next question: Is the battery capable of accepting a charge? Hauling out your battery tester, you check the battery and find that it will.

You charge the battery and the engine turns over strongly and starts quickly. But after a few starts the same problem occurs—weak cranking and prolonged starting time.

A hydrometer check indicates the battery needs recharging again. As before, the electrolyte level is okay. The battery tester indicates the battery will hold a charge, so there's only one logical conclusion. Something is preventing the battery from charging properly. What?

You check the generator (or alternator) with a voltmeter according to your service manual's instructions. It's putting out the proper voltage (seven volts for a six-volt system and 14 volts for a 12-volt system).

Next you inspect the battery posts, cables, and other ignition connections to make sure they're tight and free of corrosion and dirt. They are.

There's one more item, the generator belt. If it's loose, the generator won't turn as fast as it should to recharge the battery. Pushing and pulling the belt with a finger, you find it won't deflect more than ½-inch up or down—so it's okay.

What else might be causing the problem?

3 Hard starting in wet weather

When it rains, or the weather is damp, you're lucky if you can get your car to start. And if the engine does start, it misses badly. But when the weather is dry, the engine starts and runs fine.

Inside the distributor, the breaker points check out okay. They're gapped to spec, and aren't pitted or worn. Neither the rotor nor the distributor-cap inserts are worn. And the distributor cap isn't cracked, so no moisture is getting inside the distributor.

Next you hold a spark-plug wire ¼-inch from the block, and a strong blue spark jumps the gap as the engine turns over. That means that the coil and condenser are doing their job.

You know the car wouldn't miss without a reason. And because it only happens in wet weather, the moisture must be a contributing factor.

What's the most likely cause of the problem?

4 Engine lacks power

Your car starts easily, and runs well at slow speeds. But when you get on the turnpike and try to reach cruising speed, the engine holds back, and sometimes backfires when you hold open the throttle. Depressing the accelerator pedal, instead of resulting in smooth, powerful acceleration, produces a governing effect on the engine.

You check the fuel filter to see if it's clogged by blowing through it while it's wet with gas. (It's important to check a suspect filter while it's wet. When a filter is partially clogged, gas can sometimes obstruct it further.) You find you can blow through the filter easily.

Maybe the carb's not getting enough gas. To find out, you disconnect the gas line at the carb and insert it in a coke bottle. Your wife starts the engine (the fuel in the float bowl will run it long enough for this test), and the bottle rapidly fills with gas. So you know the carb's getting plenty of fuel.

How about the carb itself? You check it in accordance with service-manual procedures, and the float is working properly.

Maybe the vacuum or centrifugal advance isn't working. First you

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IGNITION SYSTEM

check the centrifugal advance by disconnecting the vacuum line from the distributor. That keeps the vacuum advance from operating, so when you hook up a timing light and depress the accelerator pedal the timing mark should advance as the engine speeds up. It does. That means the centrifugal advance is okay. If the timing mark had moved very little or not at all, you would have known that the centrifugal weights in the distributor were locked or frozen.

Next you check the vacuum advance by leaving the timing light connected and idling the engine at 1500 rpm. Connecting and disconnecting the vacuum line, you watch the timing mark. When the hose is disconnected the mark retards. When you connect the line, the timing mark advances rapidly. That means the vacuum advance is doing its job.

Okay, how about the high-tension wires? Maybe the insulation's cracked or resistance has built up inside the wires. No, when you raise the hood at night and have your wife rev up the engine, you see no sparks jumping from the wires. That means the insulation is probably okay. And checking the wires' resistance with an ohmmeter in accordance with service-manual instructions shows that the wires' resistance is within specs.

If the plugs were fouled or the gap eroded, they could misfire under a higher rpm load, creating a governing effect. But a visual inspection reveals they're clean. And a check with a spark-plug gauge shows they're gapped to spec.

The breaker points, too, are gapped to spec and aren't pitted or burned. When you hook up a timing light and start the engine, you find that the timing's okay.

You tick off the items you've checked looking for something you have missed. When you finish the list you're still at a dead end.

What have you overlooked?

5 Engine misses

When you drive over a bumpy road the engine cuts out intermittently. A check for loose or poor grounds around the engine turned up nothing. The coil wire isn't loose.

The ignition key feels warm when you touch it, and if you hold it firmly, the missing stops. The wires are tight on the back of the ignition switch. And the ignition-harness circuit has no loose wires.

What's wrong?

6 Poor performance

You own two cars—a new one, and a not-so-new one. Your wife uses the new car strictly for short-haul, around-town driving, things like taking the kids to school and shopping. You drive the other car. It's 12 years old, showing 100,000-plus on the speedometer, and you expect it to give up the ghost any day now.

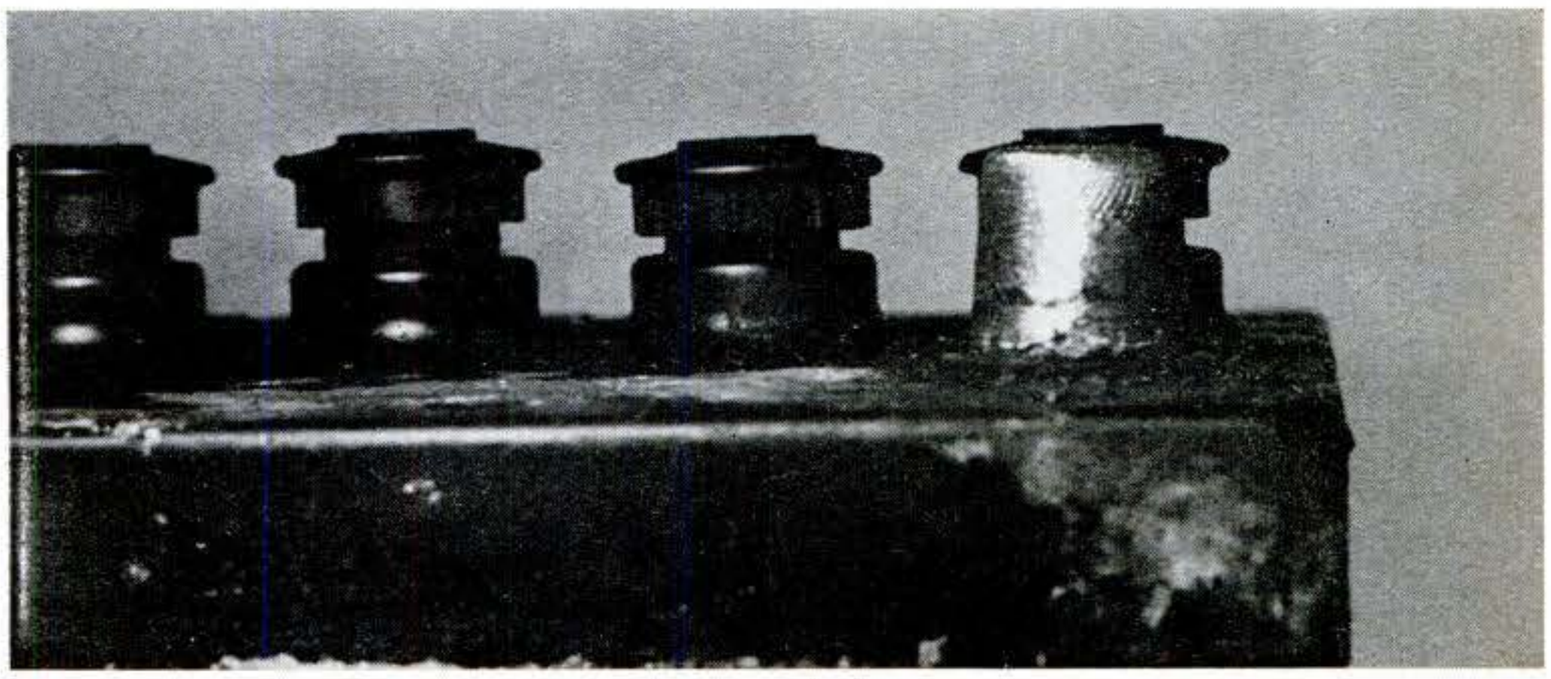
Unexpectedly one day, you get a job promotion. The only drawback is that for the next six months you must drive about 900 miles a week, mostly high-speed, long-distance turnpike trips. You can't use your car, so you manage to persuade your wife to trade cars with you—after explaining to her that she can have hers back after your six-month tour on the road. Fortunately she had her car tuned up 200 miles ago; the engine is in excellent shape.

After three weeks of high-speed turnpike driving, however, performance has deteriorated drastically. Upon acceleration the engine misses, loses power, and knocks.

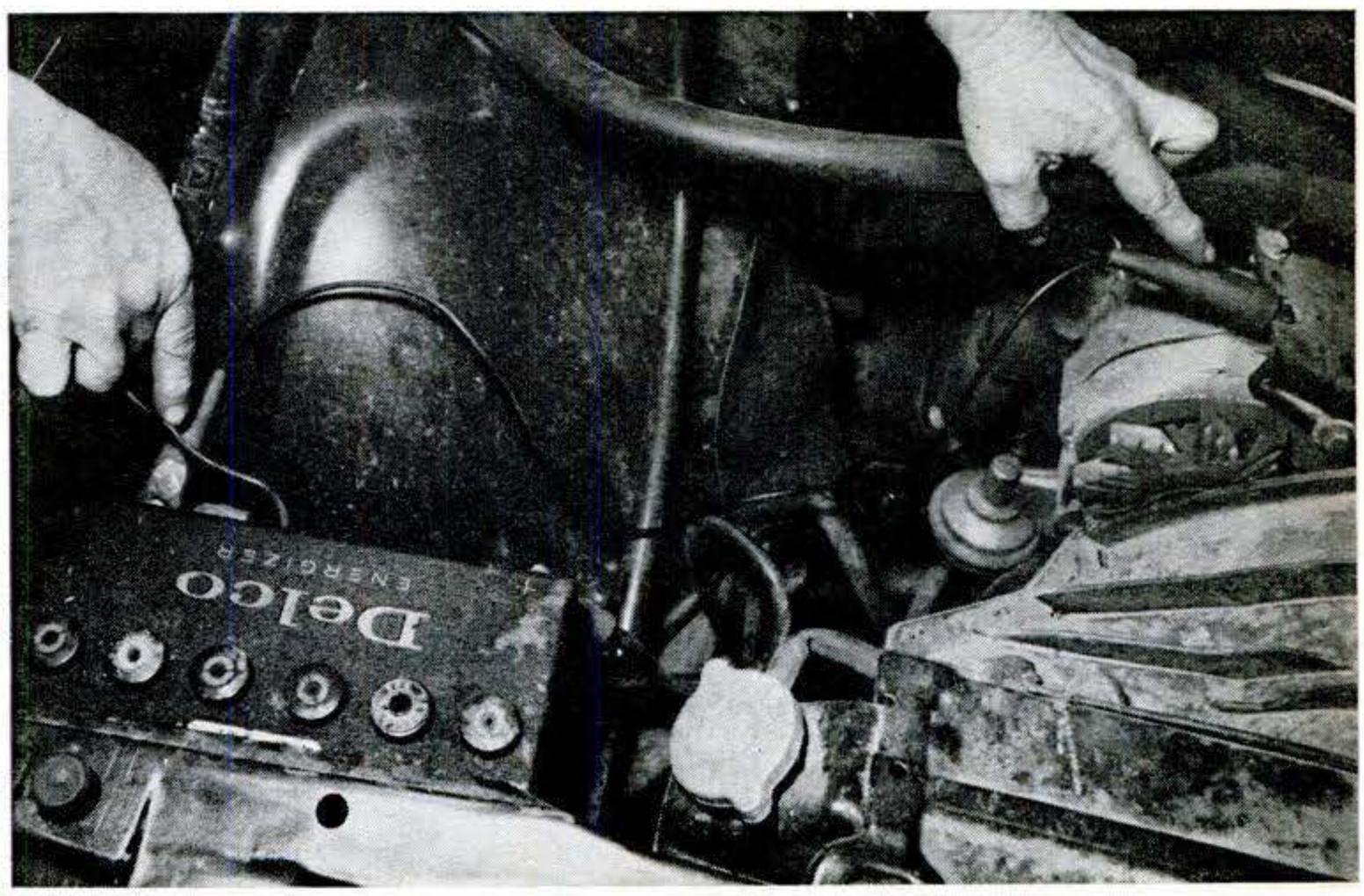
Removing the spark plugs, you find the insulators are grayish and blistered and the electrodes eroded—even though they don't have anywhere close to 10,000 miles on them. Routine fuel and electrical checks indicate everything in those departments is okay.

Why did the spark plugs break down so early?

Continued



Dirty, corroded battery posts and cables can mean a poor electrical connection, eventually causing hard starting. Clean posts until they're silvery shiny, as above.



Battery ground poor? To find out, turn on the lights and use jumper wire. Hook wire to battery ground post and car frame. If the lights brighten, the ground is bad.

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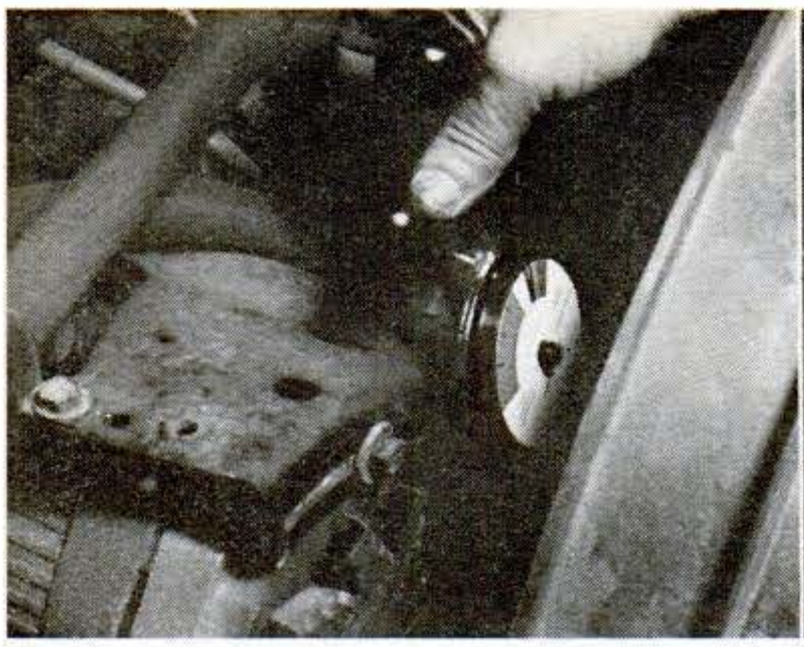
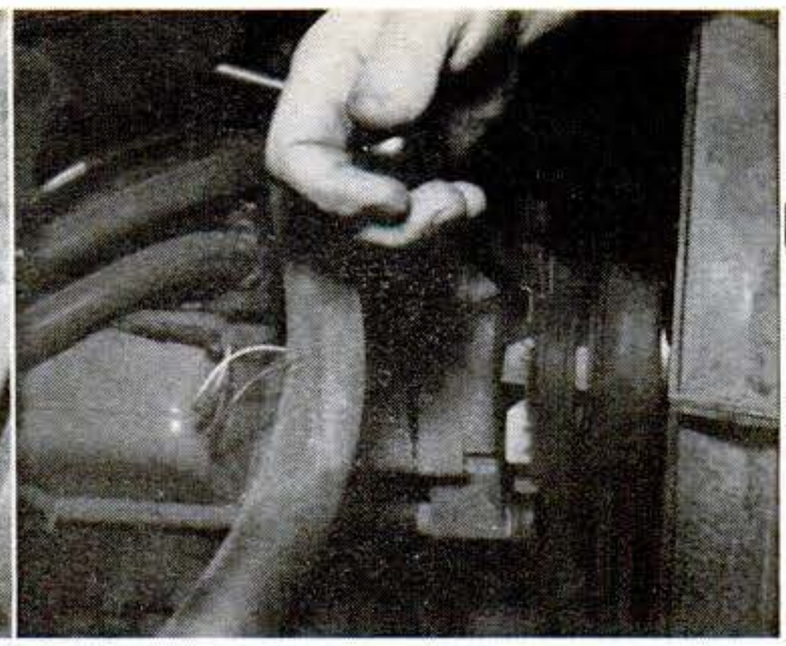
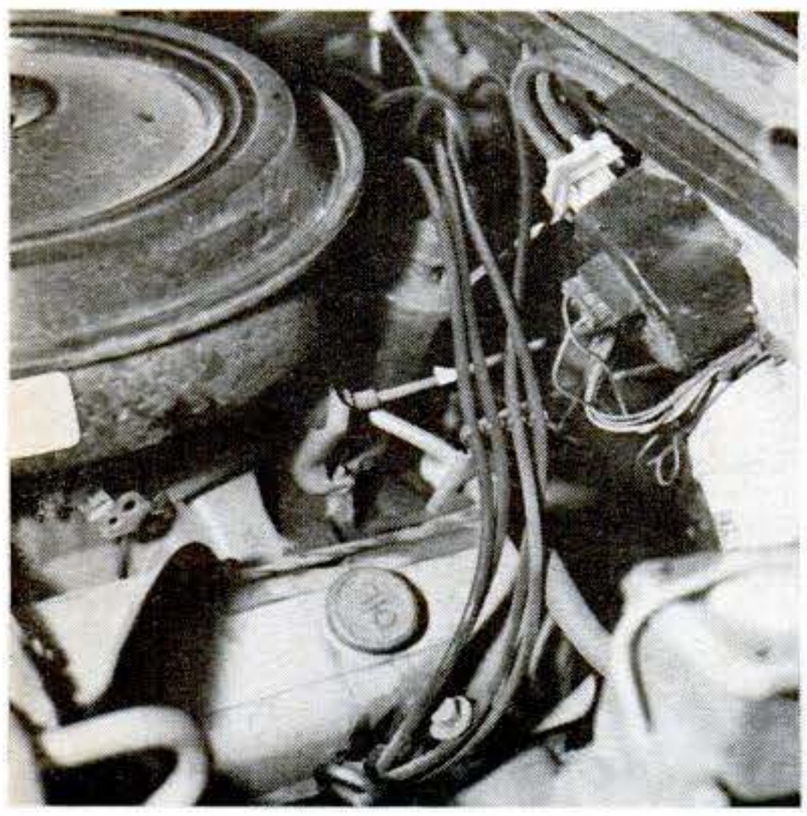


Tension gauge provides accurate method of checking to see if the generator or alternator belt is tight enough. Such gauges are available at auto-parts stores.

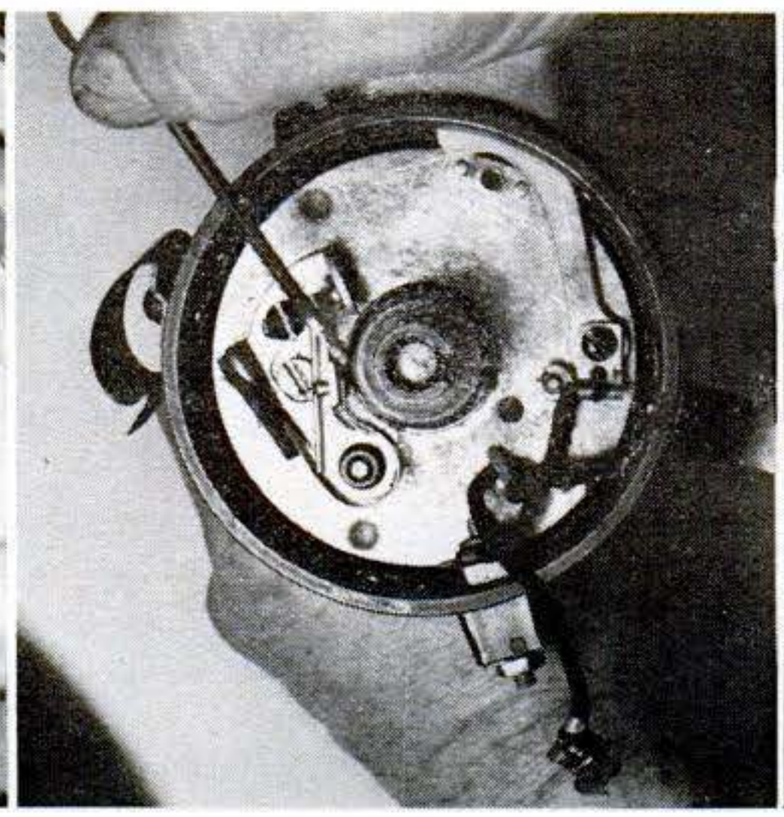


Glazed generator belt can slip, even if it's tight. To check the belt, stick a screwdriver through an opening in pulley, and push. If the pulley turns, belt is glazed.

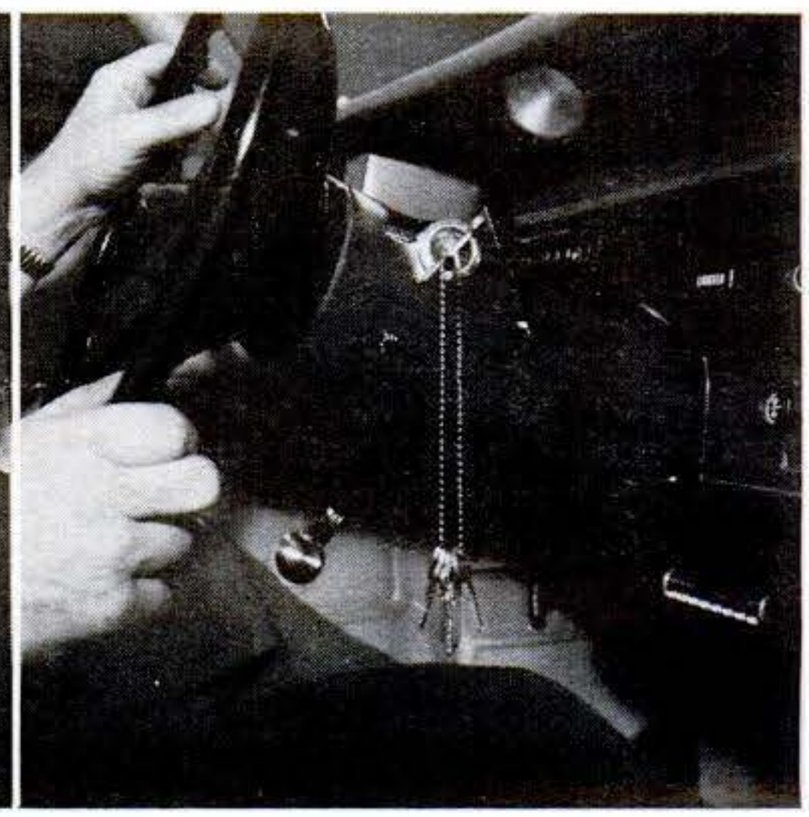
Here's what an ignition coil looks like inside. Unfortunately, it's a sealed unit, so if it becomes defective the only cure is to throw it away and buy a new one.



To check ignition-wire insulation, start the car at night and raise the hood. If the insulation is bad you'll see sparks jumping from wires to the engine block.



The distributor cam, center, should be thoroughly cleaned and lubricated at each tuneup. If it's not lubricated, the rubbing block on the breaker points will wear.



Driving with bunches of keys dangling from the ignition switch isn't a good idea. The downward pull of their weight can cause the switch to become defective.

Got the answers to the problems on the previous pages? Check yourself here

1 When the mechanic tuned up the car and installed new points, he wiped the dirt and old grease off the distributor cam—but forgot to relubricate the cam. The friction caused by the dry cam rubbing against the points' rubbing block caused the rubbing block to wear, allowing the point gap to narrow. Solution? New points. And lubricate the cam.

2 A glazed generator belt can prevent the generator from charging the battery properly. Even though the belt is tight, if it's glazed it can slip as it turns the generator pulley. The check? Insert a screwdriver between the blades of the generator pulley and try to turn it. If the belt is tight, but the pulley turns, the belt is glazed. Replace it.

3 High-tension wires have deteriorated and cracked. When the engine's wet, water fills the cracks, forming a potential short-circuit.

With the engine idling, running a test probe along each wire in accordance with your shop manual's instructions will reveal which wires are bad. When the probe passes a crack, a noticeable spark will jump to the probe. Solution? Replace the wires.

4 The coil is probably bad. Its job is to transform the battery's six or 12 volts to a voltage that's high enough to make the current jump the spark-plug gap. At increased engine loads resistance between the plug electrodes increases and the coil can't produce enough voltage to make the current jump the gap. The coil can't be repaired. Replace it.

5 Loose contacts inside the ignition switch are causing the problem. When you drive over a bumpy road the bouncing car makes them move enough to break the ignition circuit, causing the engine to miss. Holding the key steadies the contacts, preventing them from breaking the circuit. Replace the switch.

6 Your plugs broke down because they were of the wrong heat range. Remember when your wife had the car tuned up? The mechanic put in hot plugs because the car was habitually driven by her only short distances around town. When you took the car out on the turnpike and drove hundreds of miles at high speeds, the plugs broke down. For continuous high-speed driving you need to go back to a standard heat-range plug, or perhaps even a cooler plug.

"Heat range" is the speed with which a plug can transfer heat from the firing tip of its insulator to the engine's cooling system. A cold plug has a short insulator nose and transfers heat rapidly. A hot plug has a longer insulator nose and transfers heat more slowly from its firing end, burning combustion deposits that might foul the plug during prolonged idle or low-speed operation. Usually a standard plug works well. PS

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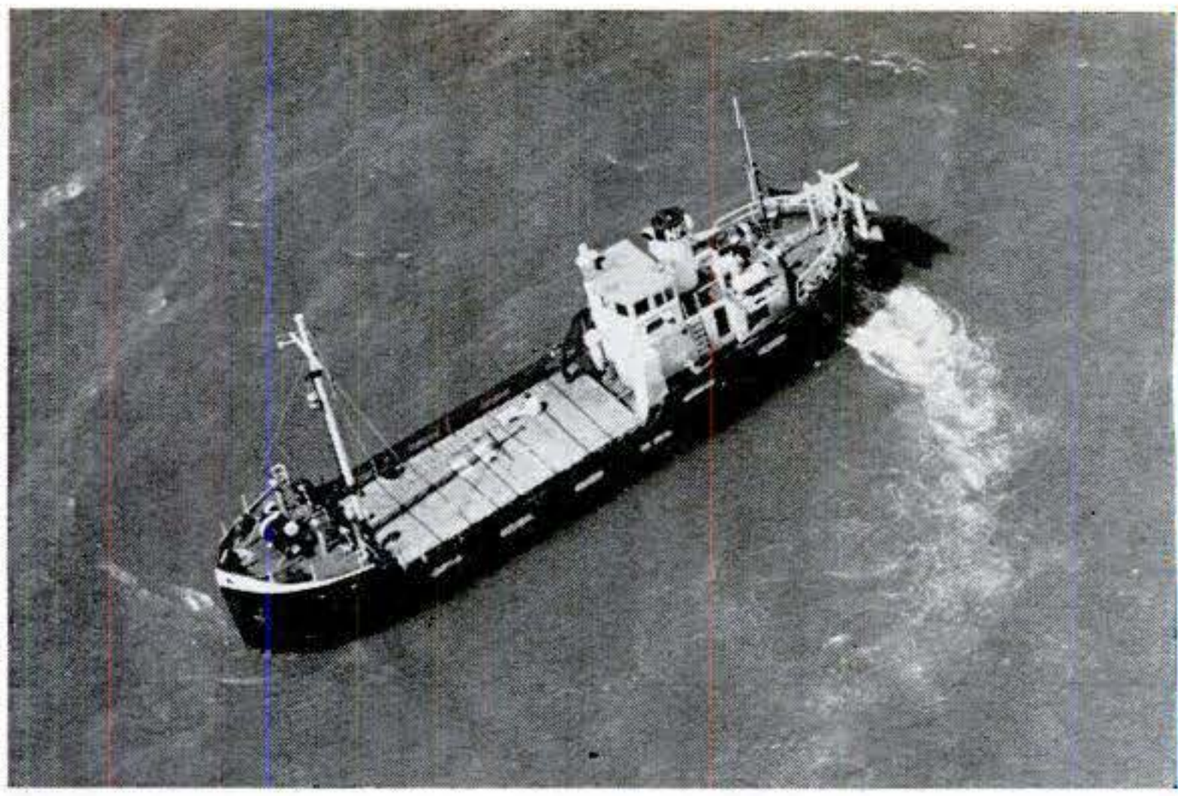
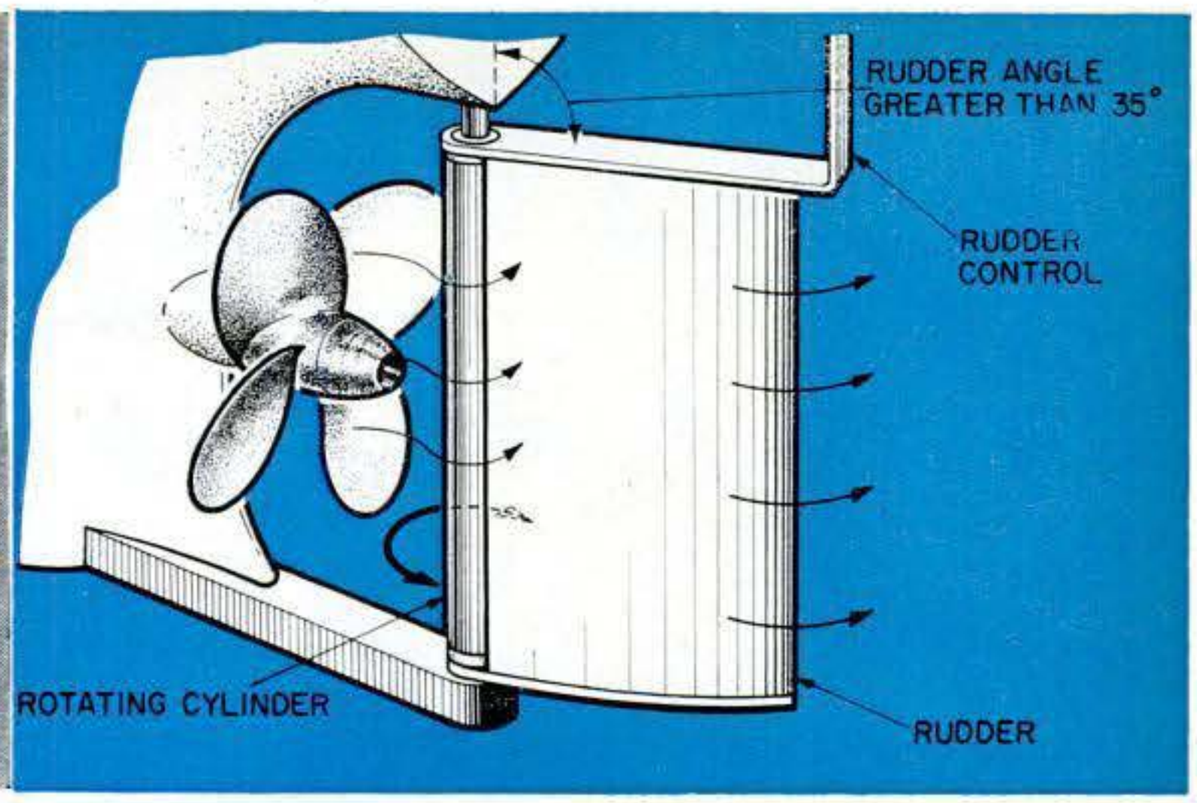




She'll chase her tail without any forward motion at all. New rudder on 200-ton cargo ship uses boundary-layer control technique used in aircraft design. Spinning cylinder diverts thrust against rudder, allowing 90-degree turns and a complete stop in seconds.

Super-Rudder Lets Super Tankers Turn on a Dime

A spinning tube on the rudder pivot could enable a 250,000-ton supertanker steaming at 15 knots to turn on its own axis if need be to avert collisions at sea or maneuver tightly into port. It could also cut stopping time to a fraction of the usual 20 minutes needed to bring these giant vessels to a halt.

The secret is an amazing rotating-cylinder rudder developed by the National Physical Lab in England.

The trouble with a conventional rudder is that when it's turned more than 35 degrees in either direction, water turbulence and flow separation behind it cut its "bite" and reduce steering effectiveness.

NPL scientists fitted a five-foot-long, six-inch-diameter tube, rotating at 900 rpm (either right or left) to the leading edge of the rudder directly behind the propeller. Hydrodynamic action of the smooth cylinder prevents flow separation and makes backwash from the prop hug the back surface of the inclined foil. The rudder can be put over to an extraordinary 90 degrees without loss of bite, and thrust is diverted at right angles to push the stern sideways.

Drive is from a reversible 3-kw motor, now hand-started. In future, the tube will automatically start spinning when the rudder reaches the critical 35 degrees.—*David Scott*

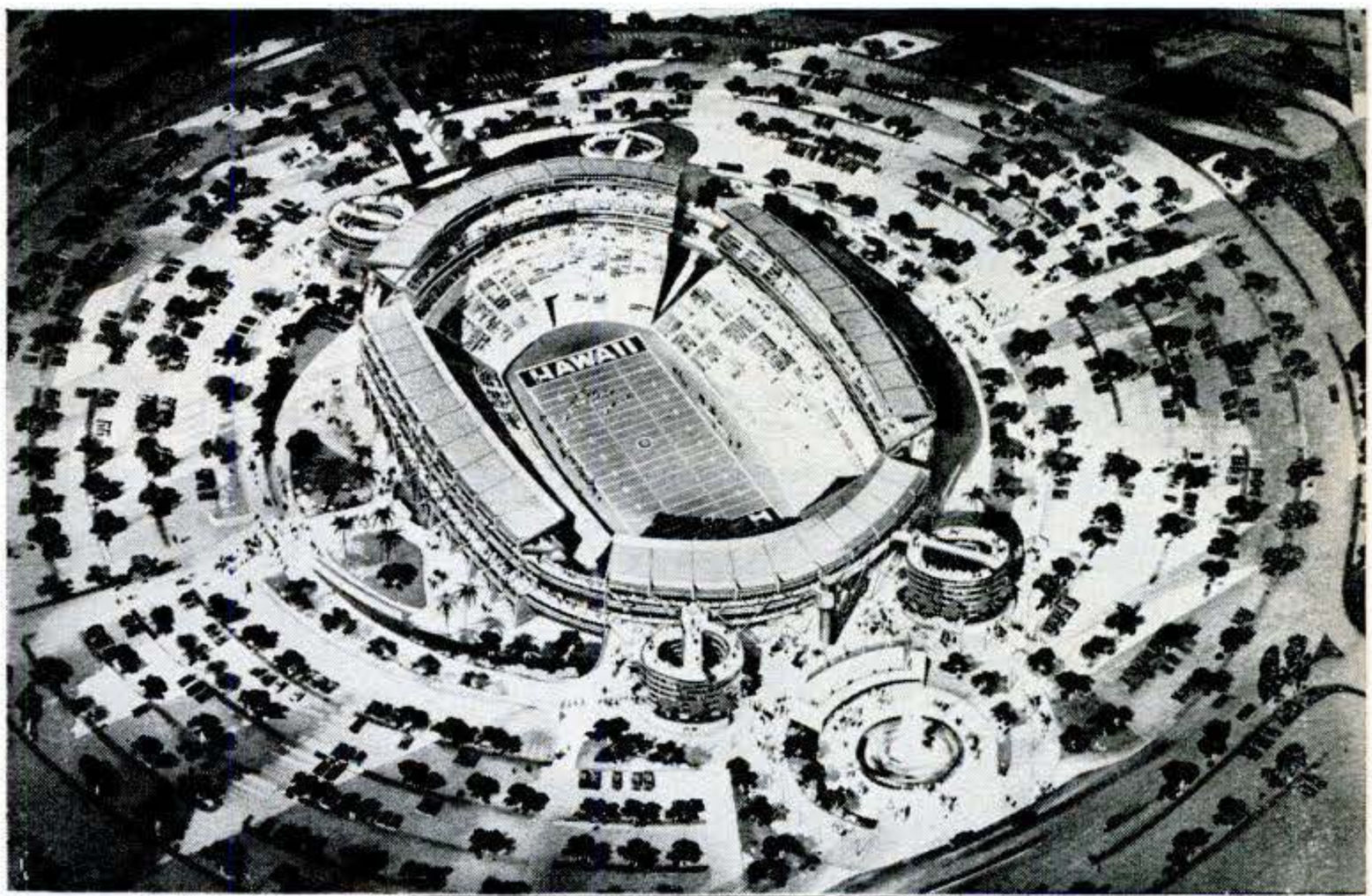
Switch-Hitting Stadium

If you should make it to the fall '73 opening of the Oahu stadium in Hawaii, you'd better double-check your tickets—are they on the 50-yard line or behind home plate? With this convertible stadium, it could be either sport you're about to enjoy.

Push the right buttons in the $27 million sports arena and air-cushioned movable stands jockey some 28,000 seats into the best position for the game at hand—baseball or football, or you name it.

It takes 30 minutes for the four 7000-seat sections to move 100 feet into position while two other stands of 11,000 seats each remain fixed. To change from the double horseshoe baseball diamond to football, the four sideline sections pivot at four points and move inward to form the curved sidelines. This puts you so close you almost join the huddle—you're only 40 feet from the action at the 50 yard line; a mere 25 feet at the goal.

Oahu is also destined to be used for soccer games and theatrical events. With a few additions, it will make a boxing arena and tennis stadium.—*W. J. Hawkins*



Oahu stadium is built in movable sections. Here it's set up for football, but 28,000 of its 50,000 seats can be shifted at will to suit the sport.

Four sections pivot and move some 100 feet on cushions of compressed air to form twin-horseshoe baseball stadium.

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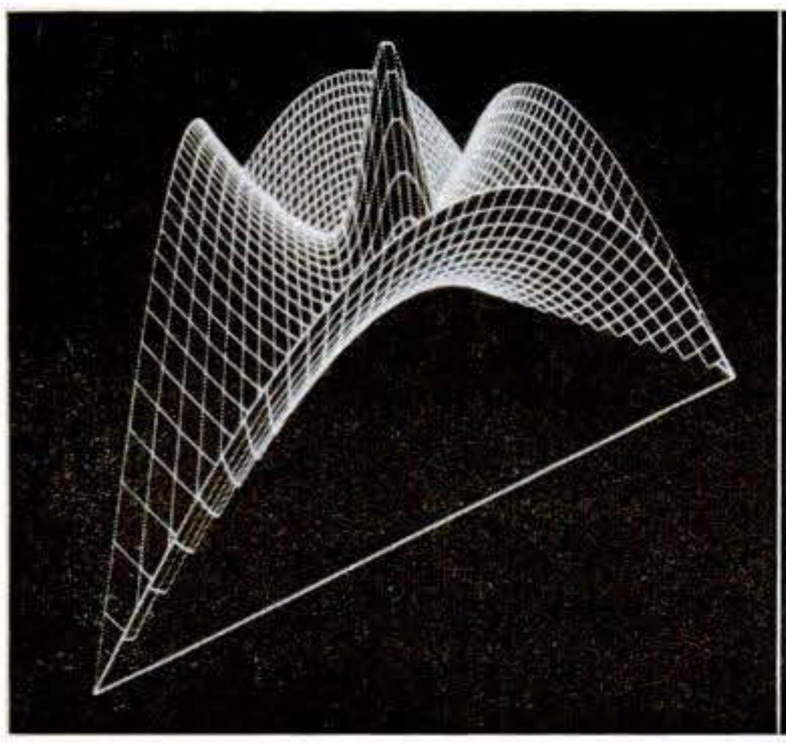
Three-dimensional graph of mathematical function is examined by author, left, who developed computer program that plots functions in proper perspective. With him is David Buckner, who designed color-filter system that presents plots in seven colors. Cathode-ray tube for computer display is just below plot sheet. Three color filters and 35mm camera for system are above graph.

Fantastic Computer Pictures

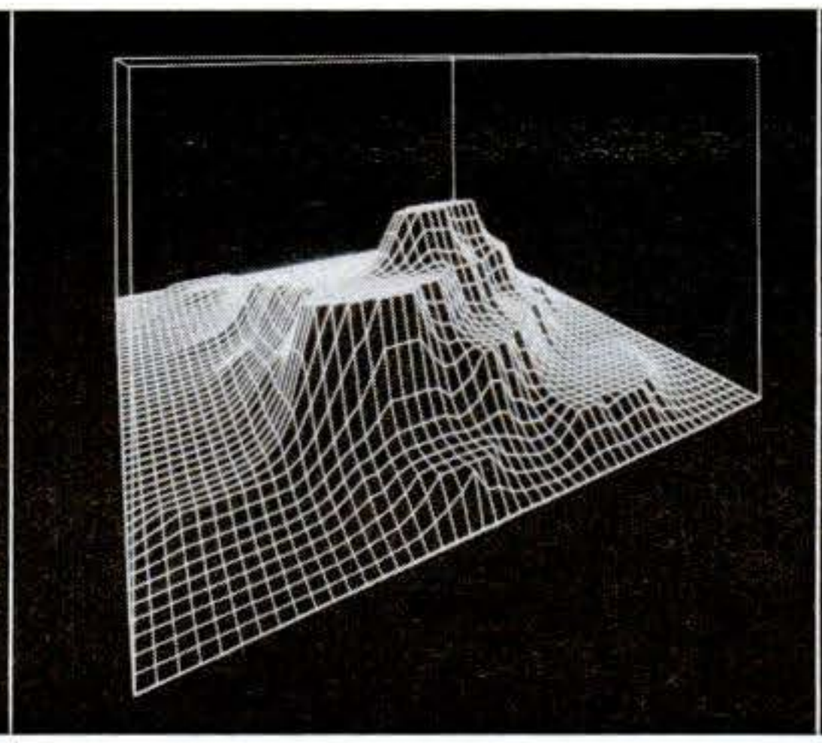
With a new computer program called PICTURE, scientists can convert streams of confusing data into colorful 3-D graphs. Creative designers may soon benefit, too

By **MELVIN L. PRUEITT** / *Los Alamos Scientific Laboratory*

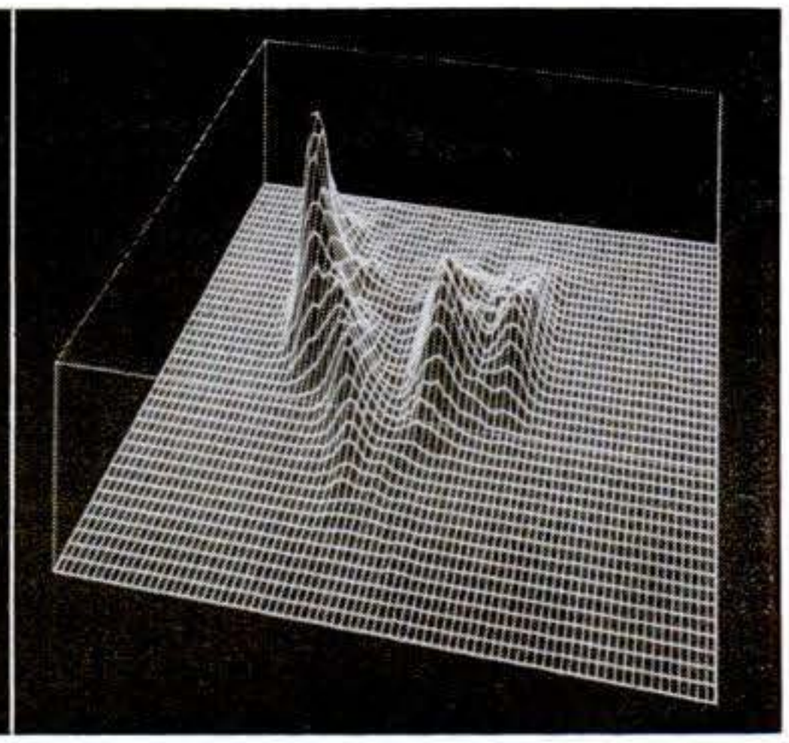
Computers were developed to handle numbers by the billions. But data that hums smoothly through computer circuits can muddle human minds. What can you see from a billion numbers?



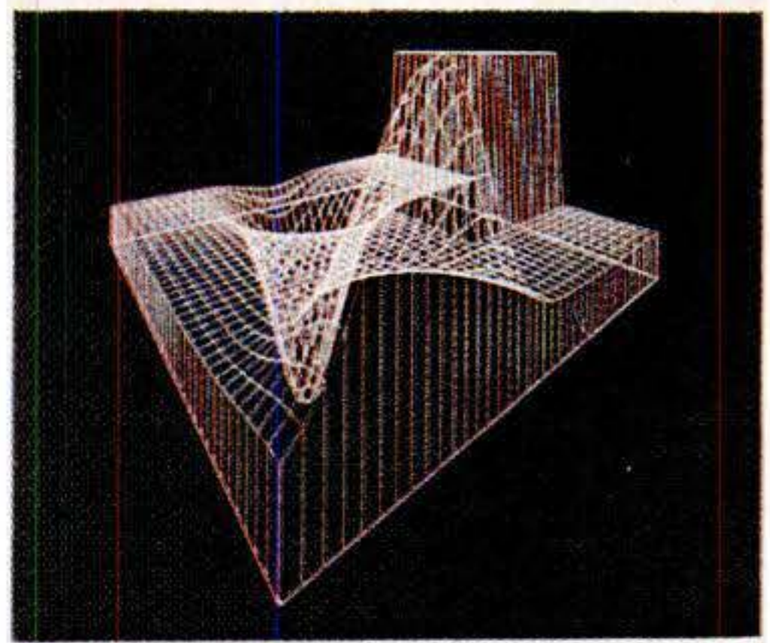
Human errors in equation-writing show up quickly with PICTURE plots. Says scientist Marlene Kopp: "Spotting an error in complex equations further complicated by computer-generated masses of numbers is extremely difficult, if not impossible." Here, mathematicians can spot equation error by the "stump" in plot. Equation should represent absolute value of saddle function.

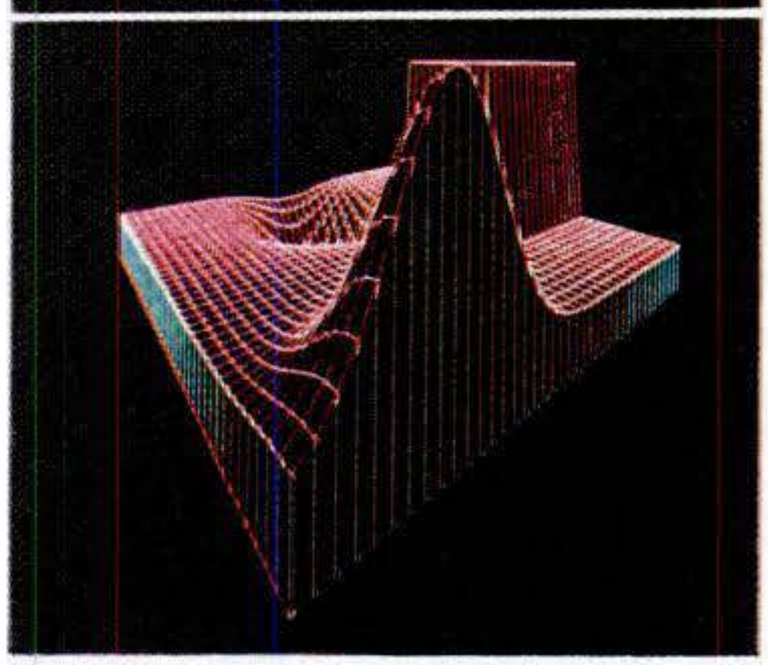


Three-dimensional plot—suggesting a high mesa in Southwest—actually reveals thickness of metal particle streaking from an explosion at 13,000 mph. A scientist made high-speed X-ray pictures of the particle, scanned the prints with a densitometer, and fed results to a computer. Transparent box can be placed around images in PICTURE plots to help the eye judge perspective.

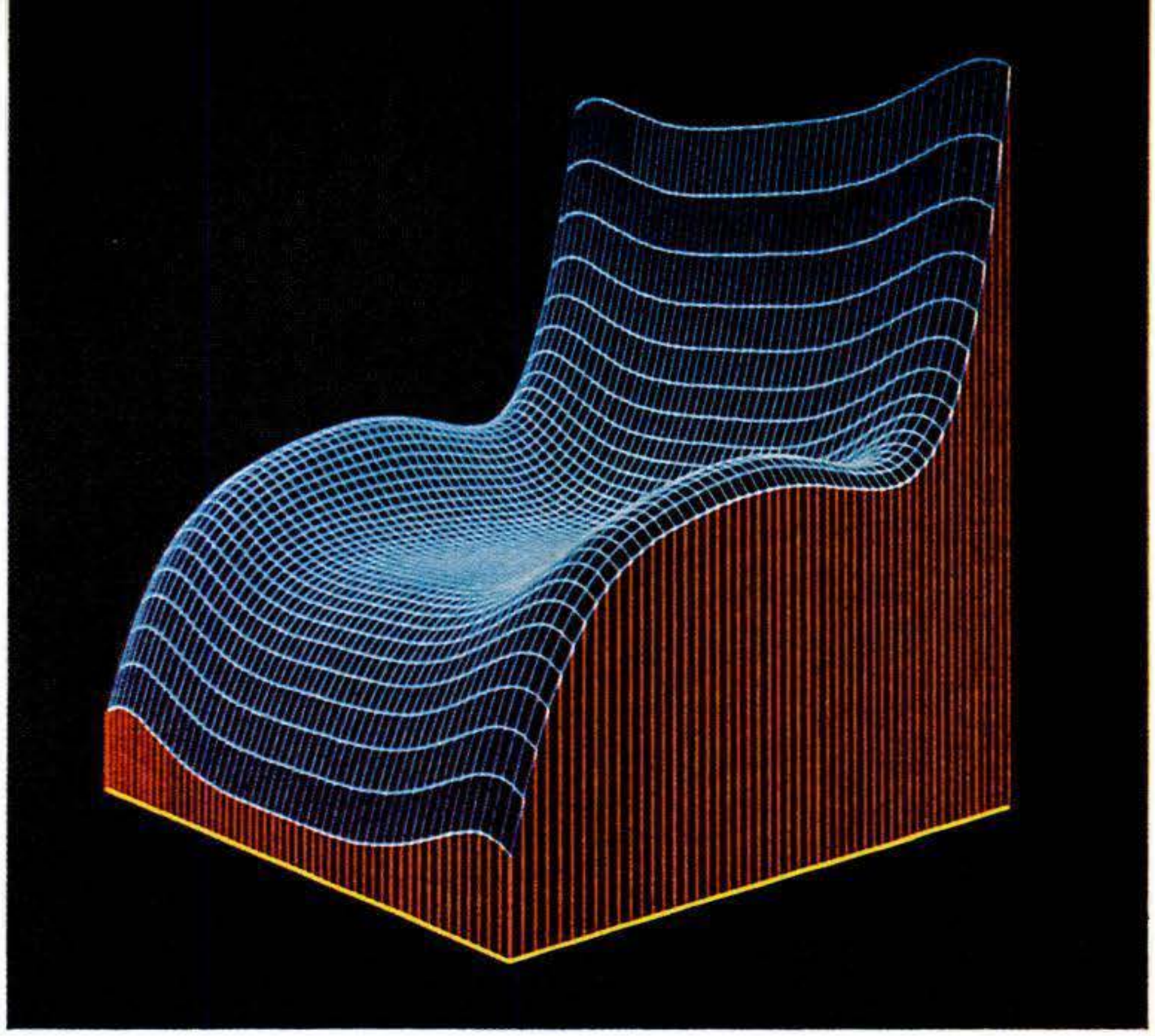


Peaked plot represents data obtained from stars to help scientists understand their evolution. Height of peaks corresponds to stellar density; temperature is measured from left to right; and motion of stars is plotted along other axis (into picture). This PICTURE display involves a complicated relationship called the Hertzsprung-Russell or, sometimes, the color-magnitude diagram.





Dramatic improvement results when black-and-white, see-through plot (top) is recorded with PICTURE technique (bottom). With all connecting lines shown, graph is confusing. Removing hidden lines, adding color provides a gain in comprehension.



Like to relax in this overstuffed equation? This plot represents the equation $[A(X-C)^4 + B(X-C)^6]/[(Y-C)^2 + D] + F(Y-G)^5 + C$. By varying the coefficients of X and Y terms in the equation, you can create different shapes. A designer—equipped with a computer—could get a quick view of a proposed shape without having to build a model. You just juggle coefficients to get ideas. By telling the computer to rotate the figure, an architect or designer could obtain different views to check shape from all angles.

Give Us a New Look at Numbers

For scientists and engineers, these computerized numbers often represent variables—temperature, angle, wavelength, time—in mathematical formulas that describe physical processes: a rocket ignition or a distant star's life cycle, for example. If instructed to translate the numbers into pictures, computers gain tremendous additional value as research tools.

At Los Alamos Scientific Laboratory, we attacked the problem of visually displaying mathematical functions after discovering computer programs already available for the job were inadequate.

Color graphs. What resulted is a new computer program dubbed PICTURE. Now scientists can see clearly—in seven different colors—three-dimensional graphs.

Graphs can be produced representing anything from the shape of a magnetic field, or ripples in a shock wave's changing pressure, to the time-dependent solution of a differential equation. Color movies can ever portray the "life" of a functional relationship as variables change.

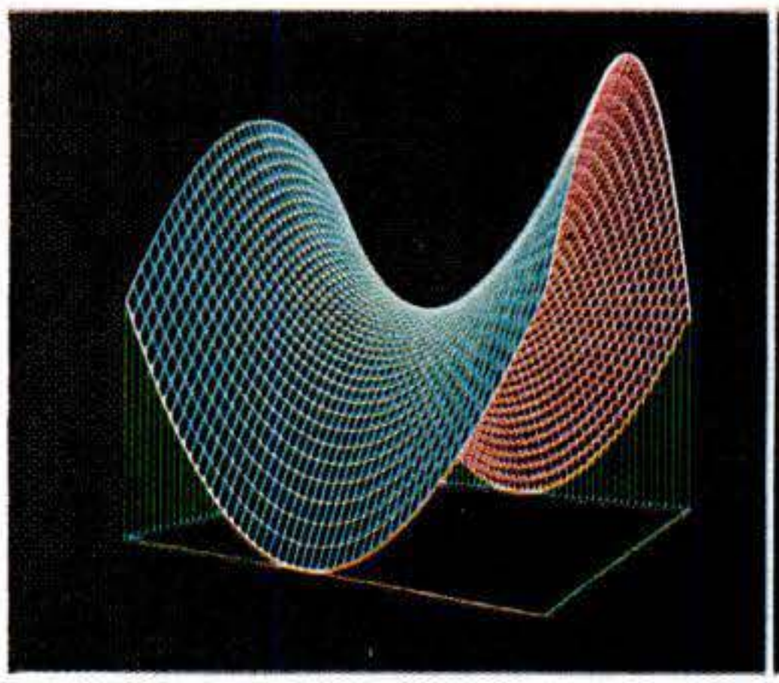
PICTURE grew out of my struggles with a problem on hypersonic wind flow that produced staggering quantities of numbers. Each minute a computer spewed out 41,600 new numbers that I had to analyze for velocity, temperature, pressure, and other variables at 1600 points in the flow path. I had so much information, I knew nothing!

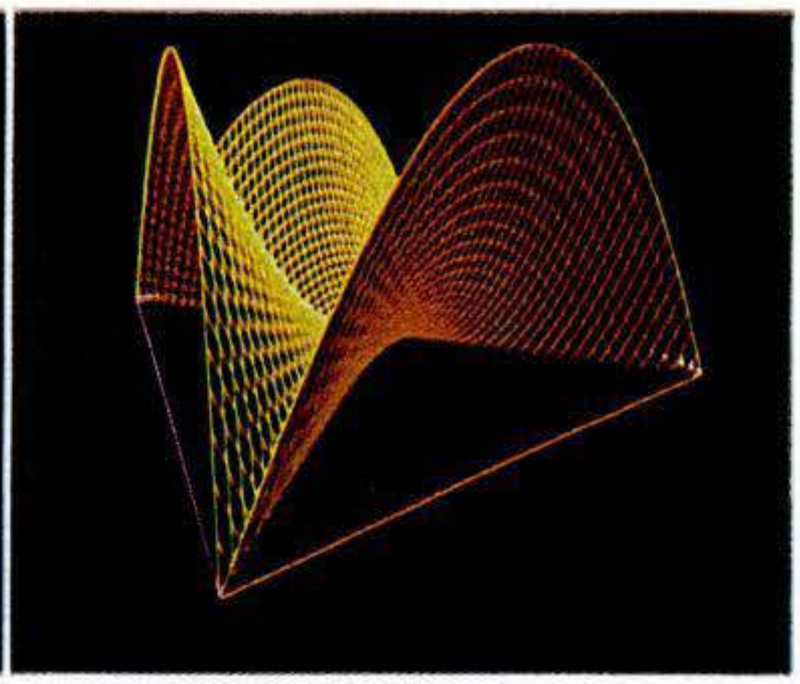
First I plotted the numbers as a surface in perspective. Surface height represented a variable's value at a given point; a bump designated a hot spot. But the cathode-ray tube (CRT) displaying the computer plot showed both sides of a bump like an X-ray picture—a mass of twisted lines. I needed to get rid of hidden

Continued

ABOUT THE AUTHOR

Dr. Prueitt, a staff scientist at the Alamos, N.M., laboratory, tells in this article how he developed the system that produces these striking pictures and explains their importance.





Mathematical "saddle" function is much easier to grasp in the plots above than by looking at its equation: $F = A[(X-C)^2-(Y-C)^2] + B$. Vertical sidebars are removed to show underside of plot. Minor equation changes for absolute values produced plot on right.

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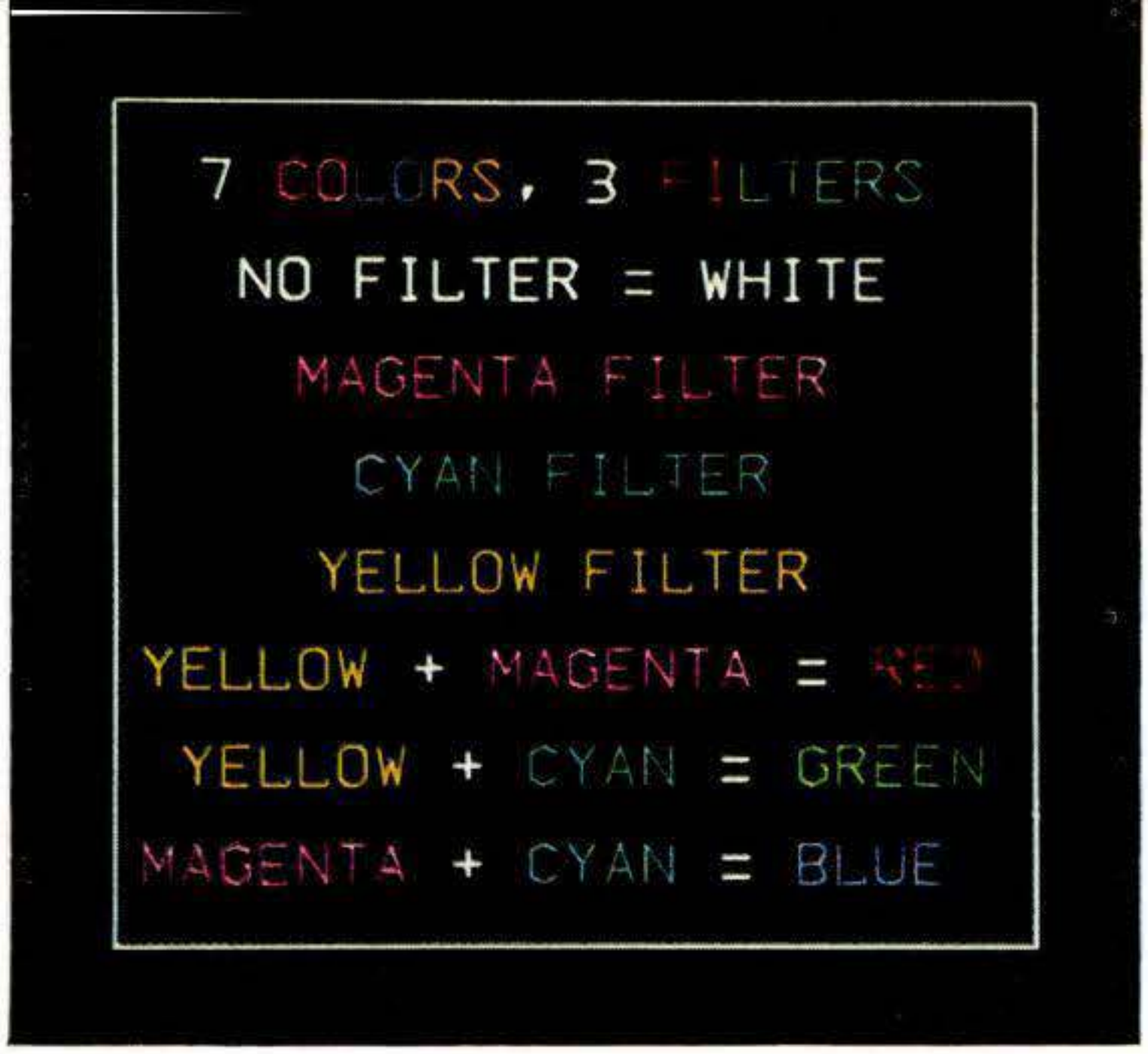


Three-filter system, utilizing complementary colors yellow, magenta, and cyan, produces seven colors (including white). Electrical impulses generated by the computer program move filters in and out of the light path to a camera. Lines are produced by computer-controlled electron beam in a CRT somewhat like a B&W TV tube.

lines in back (photos, top left, previous page).

This hidden-line problem had been treated by many people, but available programs consumed too much computer time. On LASL computers, plotting a two-dimensional array of 3280 connected line segments required from 30 seconds to a minute or more. Completed, PICTURE plotted the array in .64 second.

You can approach a mathematical array of numbers much like a chess set: Chessboard squares correspond to squares on graph paper. The board edges represent the X-Y coordinate axes of a graph. Chess pieces represent numbers or elements of the array; figure heights are their Z-direction numerical values, the third dimension. A thin plastic sheet placed lightly over the chess figures would form an irregular surface.

The surface, viewed from an angle, would present peaks and valleys formed by kings, queens, bishops, etc. Taller figures nearby hide shorter figures, while tall figures in the background thrust upward like mountains.

Stretching soap films. This multidimensional surface is the image scientists and students have tried to visualize for years. To "see" and "feel" various functions, mathematicians have molded clay and carved wood to their shape. For a brief, shimmering view of an imaginary surface, some have even stretched soap films over wire frames. One expensive technique uses a computer-operated machine to carve out function blocks. Students pull colored strings through boxes to form intricate geometrical patterns.

Problem: How could I teach the computer to show what I could see from a point outside the chessboard? I hit upon the idea that a line projected on a vertical plane placed perpendicularly in front of the chessboard would provide a perspective image of all "bumps" visible from that point. This meant that a foreground line projecting a higher image than a background line should hide the rearmost line. Similarly, a high background line would show up if nothing in the foreground obscured it.

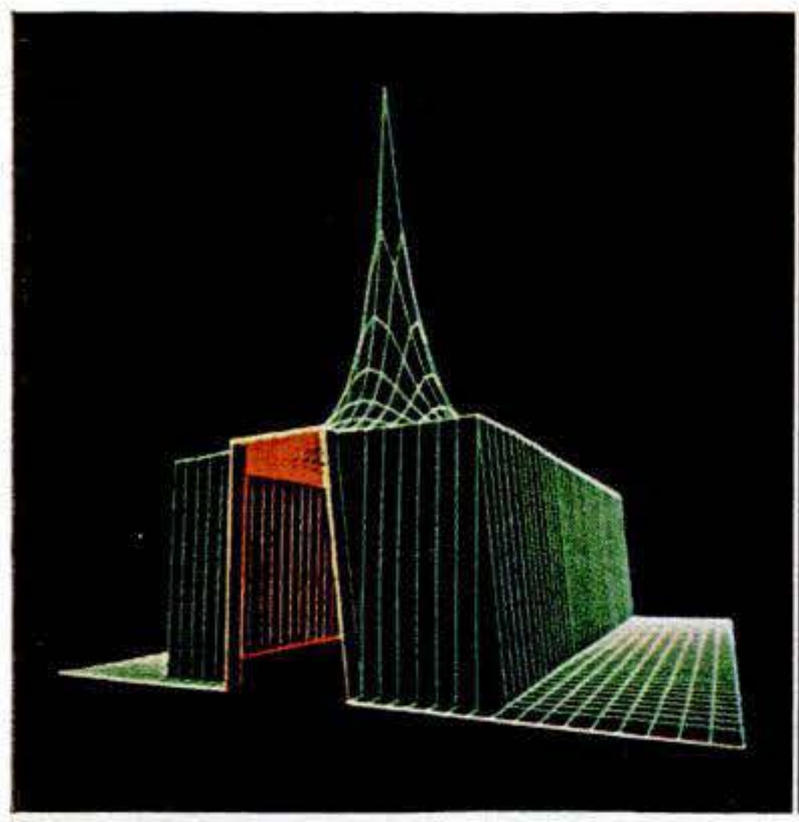
Tucking in lines. But telling the computer how to remove hidden lines was a problem. Early messy versions of PICTURE had lines sticking out like pins in a pincushion. Grinding away at one modification after another was necessary, tucking lines in and making segments stand out where necessary.

Finally, the program boiled down to examining line segments by coordinates. Remember the grid pattern formed by chessboard squares? A technique was developed to first check all Y-direction segments and lines in adjacent squares. Then the computer was told to examine X-direction segments and lines at the near and far sides of the squares.

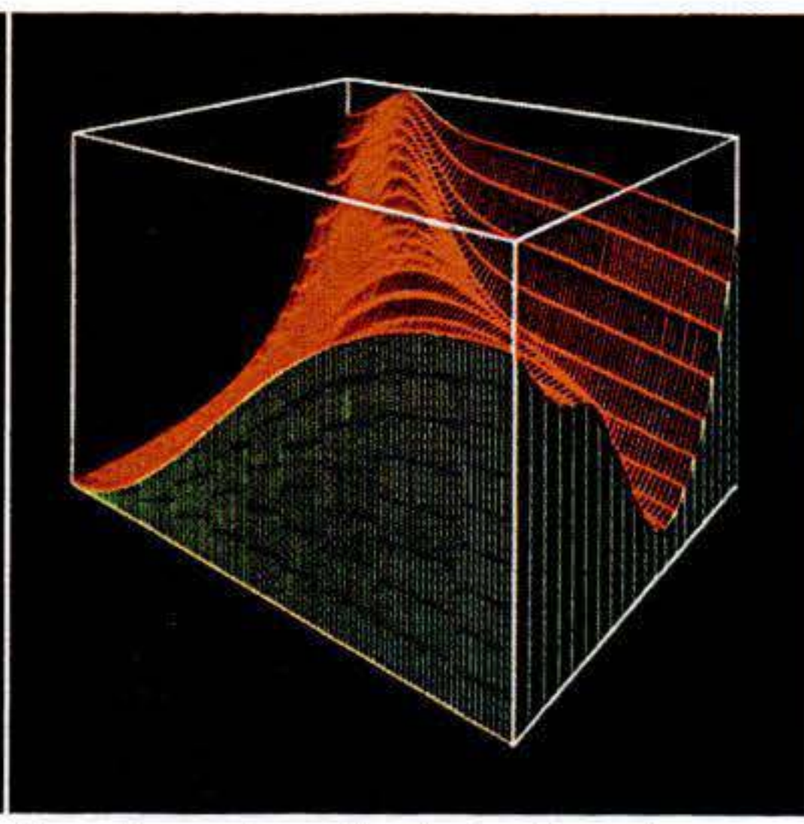
Segments were checked for visibility, beginning with lines nearest the viewer and working away. To save time, a flag was set for each segment: visible, partially visible, or invisible. Now the computer checked only segments between the viewpoint and a segment in question for visibility. No further checking was necessary if the segment was higher than a line nearer the viewer flagged visible.

If the segment was hidden by a line, the line's index was saved. Consequently, when the computer checked the next line segment, it first tested the indexed line to see if it hid the segment. The computer could then decide whether to go through a visibility check or skip the segment.

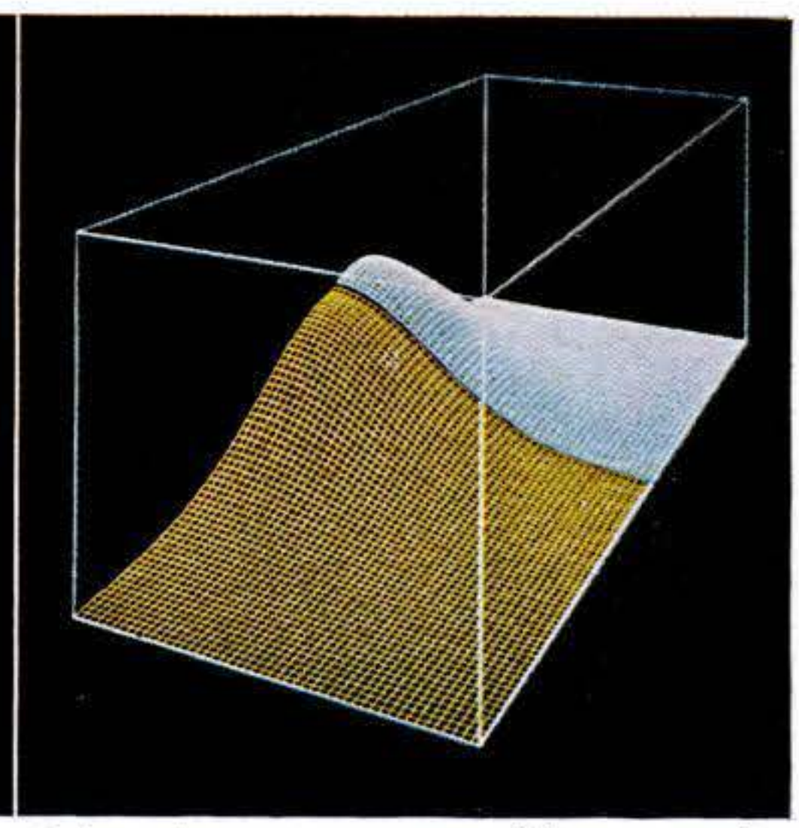
See-through box. In addition to this time-saving feature, PICTURE also has the option of placing a transparent box around the computer plot to aid the eye in judging perspective. The X, Y, and Z axes can be labeled or not, according to their visibility. Vertical sidebars from plot edges to the base also aid perspective defini-



Cathedral was built in a split second by adding a simple mathematical function and constant to part of a flat array. PICTURE display is even complete with a green lawn.



Laser-beam absorption by hot deuterium gas is shown above (see text). Firing angle is measured along front edge, penetration front to back. Height shows absorption.



Color changes represent different media carrying a laser pulse. Plot shows size and shape of pulse moving down a laser. Distance from laser's center is left to right.

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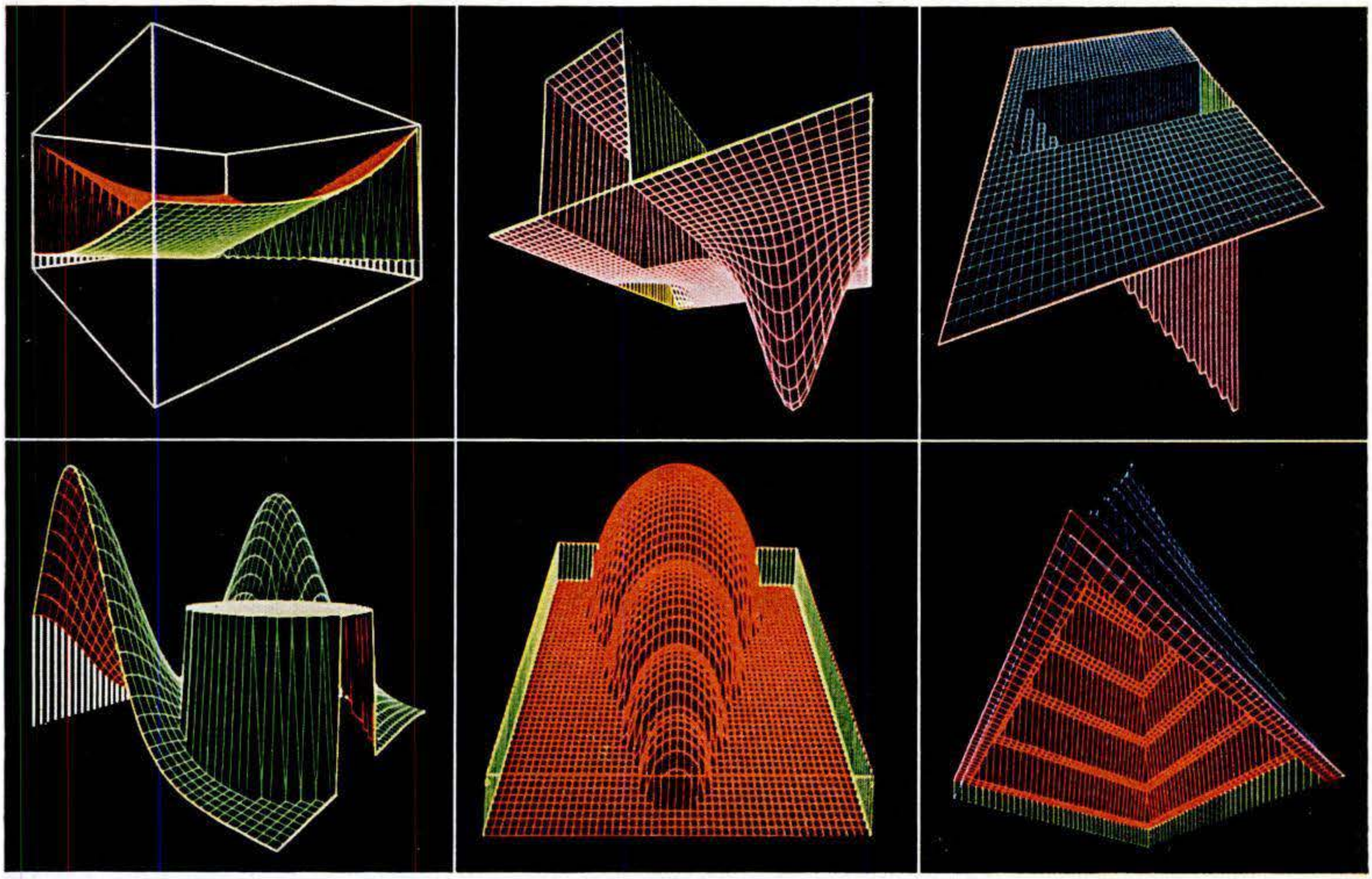
A gallery of colorful graphics: Computers turn numbers into teachers



tion. Sidebars make images appear solid, as though carved from wood.

Still one more refinement, I thought, would provide greater clarity. Sometimes it's difficult to tell the top surface of a black-and-white plot from the bottom surface. Color was the answer. Why not paint the two surfaces different colors?

David Buckner, a computer engineer, developed an electronic color-filter system for LASL that enabled me to generate plots in seven different colors (see photo).

Buckner's system, using signals generated by the computer program, moves combinations of color filters—yellow, cyan, and magenta—between the camera and CRT. As the photos on these pages show, color brings a new element of clarity to computer plots.

A fourth dimension. PICTURE adds still another dimension to plots: time. The brain has the amazing ability to convert two-dimensional information you see into three dimensions. Time, however, must be experienced. Movies of PICTURE plots give us two- and three-dimensional images that move in time.

Applications for the new program are plentiful at Los Alamos, a basic-research laboratory operated for the U.S. Atomic Energy Commission by the University of California.

One LASL explosives expert, Stan Marsh, wanted to know the shape of metal particles leaving a target blasted by high explosives. Marsh estimated chunks were hurtling away from the blast center at 13,000 miles per hour. He took a high-speed X-ray photograph of an event and fed data into a computer. The computer used PICTURE to give him individual particle shapes.

Blasting plasma. Another researcher asked what would happen when he blasted a hot gas of the hydrogen isotope deuterium with an intense pulse of laser light. If the hot gas absorbed the light well, the temperature could jump to 100 million degrees, where nuclear fusion occurs and large quantities of energy are released. If a man-made reaction—controlled—can be produced, a new source of energy will be available. Many laboratories around the world are working on this problem. Since hydrogen and deuterium are a part of water, one can foresee fusion reactors producing great quantities of energy from the oceans.

One scientist did some computer calculations relating energy absorption to penetration depth and the angle at which the beam strikes the surface of deuterium plasma (a hot gas). By plotting some 2000 numbers with PICTURE, he showed how the absorption of energy changes with the change of the angle of laser-beam incidence.

Says scientist Dr. Marvin Mueller of the plasma perspective plots: "Only in this way can complicated relationships be visualized. Indeed, in a few cases, the 3-D program led to the discovery of relationships that would have been undetected otherwise."

Pulse shapes. LASL scientists Don Dickman and Dr. Bergen Suydam used the computer to calculate the dynamics of the laser itself. They wondered what "shape" the laser pulse would take. Did it distort, and how did its strength change?

Again, they ran into many numbers with their computer program to get a clear idea. By getting Don's program to "talk" with PICTURE, they found they could see the shape of the laser pulse in color (photo).

One of the most useful tools of research in astronomy is a complicated mathematical device called the Hertzsprung-Russell diagram. Dr. Eric M. Jones made 3-D plots of reduced proper motion against temperature for a large number of stars. Their distribution in the H-R diagram can reveal a great deal about stellar evolution—how stars were born. In the PICTURE plot the star densities look like a mountain range dominated by sharp peaks of brightness,

[Continued on page 152]

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How Much Power? Matching a Motor to Your

Starts here: six pages of new '73 rigs to help you find what you need

Power—and lots of it. That's what too many inexperienced boat buyers go for, no matter what the size of their boat or how it will be used.

Speed is exhilarating—one of the reasons why people buy boats. But most of us, for our days of skiing, fishing, cruising, or just poking about, do not need a boat powered to the top of its range. And an *overpowered* boat is downright dangerous. So is an underpowered boat that has to get you

Fifty horses is enough to get two skiers up. The Evinrude 50 costs about $1000, burns just over five gallons per hour at full bore.

RUNABOUTS and SKI BOATS

These are boats the family will use. They are safe enough for the wife and kids on Sunday afternoon, and they'll satisfy your speed-and-spray urges. Length ranges from about 15 to 23 feet. Such a boat needs to be narrow enough (eight feet or less) for unrestricted towing on highways.

Outboard power in this category starts at 25-30 hp and goes up to 150 hp in single or twin installations. Stern-drive power ranges from 100 up to 200 hp or more.

These rigs can be found at almost any price you have in mind. A 40-hp outboard motor costs about $750. A good 18-foot boat, weighing about 850 pounds, will cost about $1400. Stern-drive rigs cost more. An 18-foot boat with 170-hp stern drive will run about $4800. A 21-footer with a jet pump capable of driving her at 50-55 mph will carry a price tag of about $8000.

Hull configurations in this group are mostly of two types: a deep V or some modification of it, or a cathedral hull. Deck designs are varied; choose to suit your needs. Bow-riders continue to enjoy great popularity.

The 18-foot Grady-White Adventurer lists at $2245, is rated up to 170 hp. She tows two skiers with new Johnson 115.

For the Glastron V-156 (left), suggested horsepower is 65, maximum 85. V-187 Swinger (right) has 170-hp I/O, costs $4808.

Boat for Your Needs

By JIM ROE / *PS Boating Editor*

home when you're out on big water.

How do you know what's right? First, pay heed to the maximum horsepower ratings assigned by the Boating Industry Assn. If you stay within these ratings and practice sensible boat operation, your boat should give good performance and safety, too. Key your selection to the kind of boating you plan to do and the waters in which you'll do it. For this, there is no formula.

To aid your selection, PS has assembled six pages of 1973 boat-motor combinations. Outboard prices, suitability, performance, fuel consumption, and ease of installation are recapped in a table at the end.

Big Wellcraft 185 Airslot, pushed by a Mercruiser 165-horse stern drive, is a roomy, go-anywhere boat with plenty of power.

Cruisers, Inc., Great Lakes sport boat is powered by OMC stern drive. Hardtop provides shelter, leaves open cockpit space.

Chris-Craft's Lancer 19, designed by Jim Wynne, is fit for rough water. Several stern-drive power options are available.

Power for Starcraft's 15-foot Nova ranges from 35 to 65 hp tops, with speeds from 25 to about 38 mph. Suits skiing well.

Checkmate MX-16 with a 135-horse Johnson will go 52-56 mph. Yet she'll perform well (39-43 mph) with only a 65-hp motor.

Twenty-foot Formula with 115-hp Evinrude turns in a superior performance, with power to spare. The V4, 99.6-c.i.d. engine weighs 262 pounds, costs just under $1600. High-speed fuel consumption is probably a bit over 11 gallons per hour.

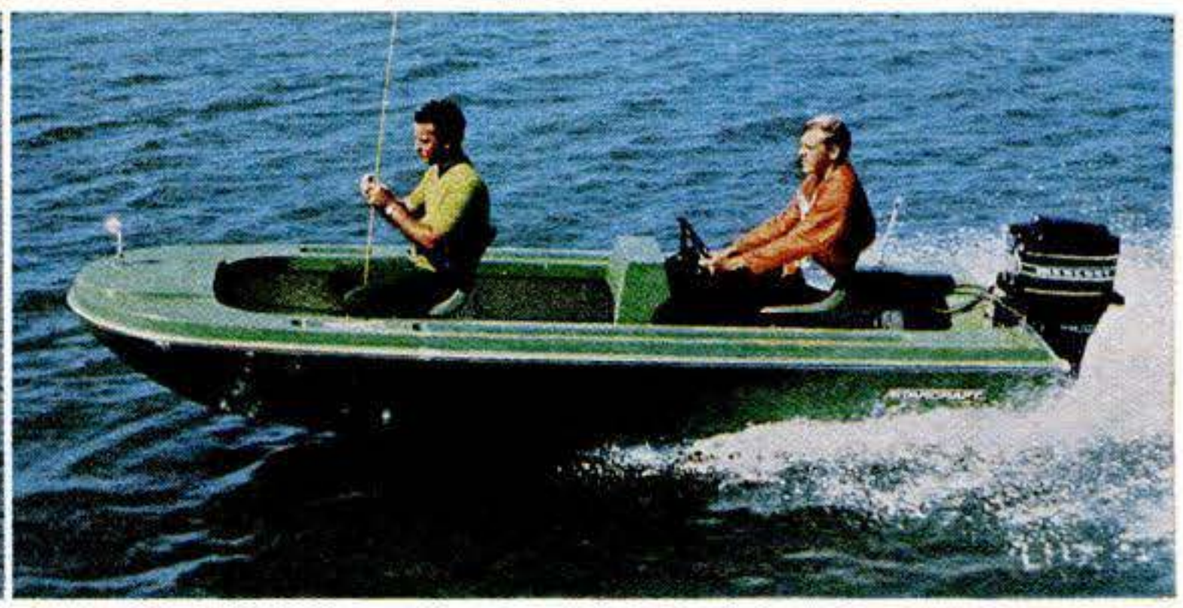
The Caravelle demonstrates the popularity of a bow-rider. Even with wall-to-wall people, Evinrude 115 is more than ample.

Winner's bright-yellow bow-rider with V hull turns in a smooth performance with medium hp Mercury outboard. **[Continued]**

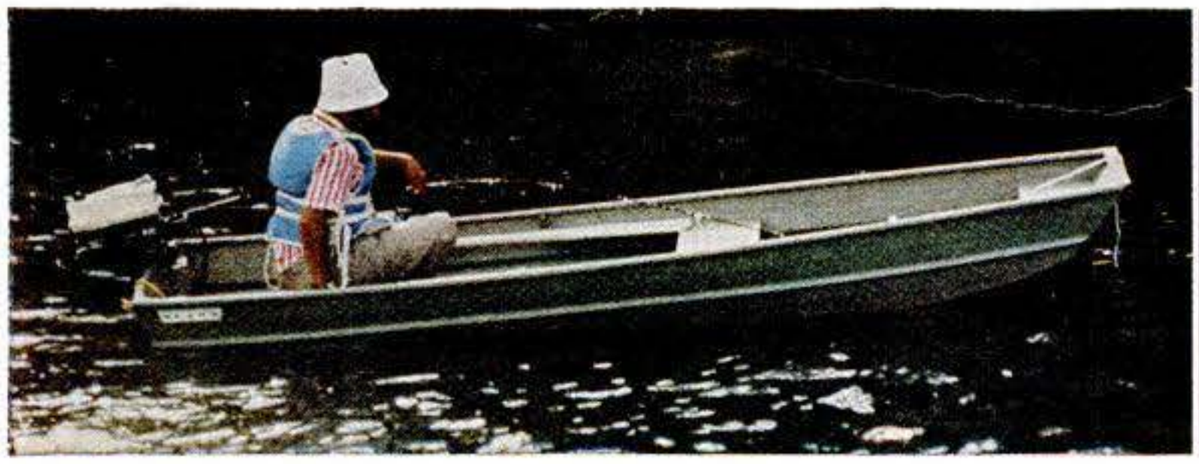
INLAND FISHERMEN They are designed and built for quiet rivers, the bayous, and the smaller lakes. Many small fishing boats are remarkably stable under tough conditions, but a prudent boatman will not challenge big waters in them. Here is where horsepower ratings should be carefully considered. For instance, many fishermen dangerously overpower the highly popular new bass boats. Smaller aluminum fishermen and johnboats provide a world of fun with a motor as small as four to seven horsepower. Light weight (many under 200 pounds) and low cost (several are less than $400), these boats and motors sell by the hundreds of thousands. A good many can be cartopped. And they bring home a lot of fish!

The classic bass boat in classic bass water. Evinrude 65 provides all the power this boat should have. Don't overpower it!

Power's complete: Sears 14-foot Gamefisher (only 132 pounds) has suitable 7.5 Sears outboard plus electric troller out front.



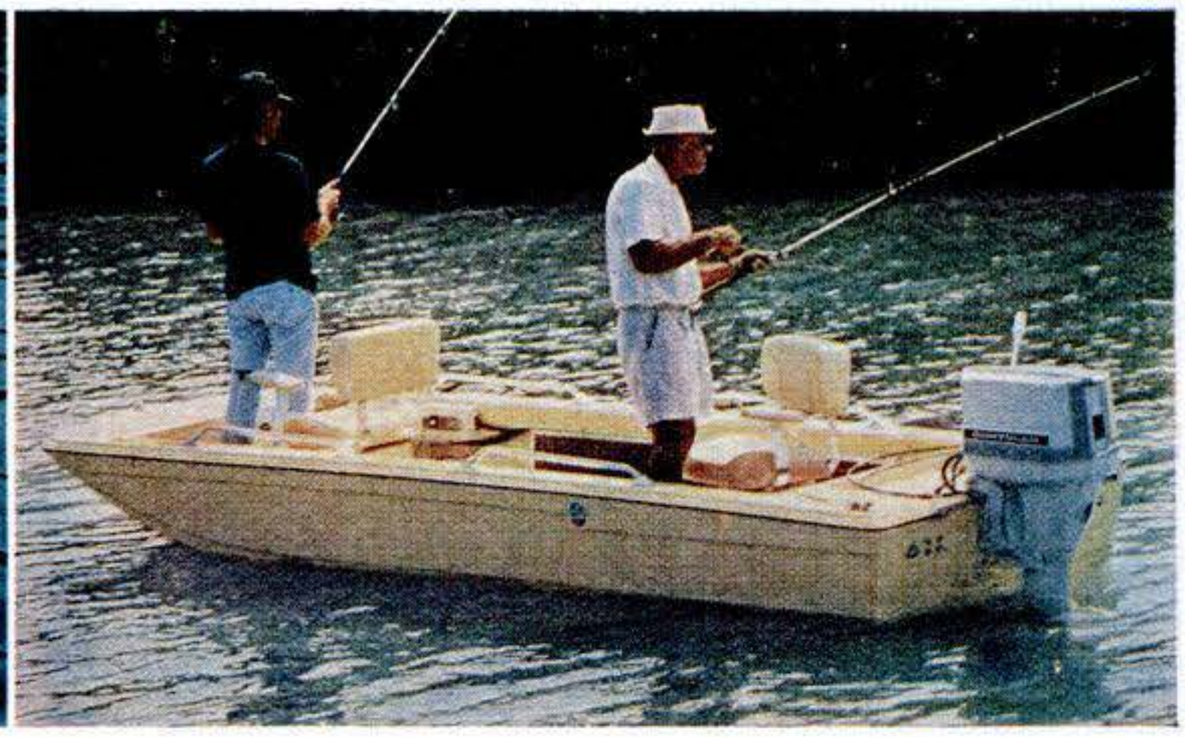
This is Starcraft's 14-foot Fish N'Ski, with 50-hp Merc. A new 16-footer for '73 has two live wells, lockable tackle storage.



Serviceable aluminum johnboat from Sears is 12 feet long, and easy to cartop. Motor is a 4.5-hp, enough for this boat.

Lund's 14-footer weighs less than 200 pounds, but will carry four fishermen and gear. Evinrude 9.5 weighs 60 pounds.

The minimum fisherman for quiet waters should give secure seating with two aboard, and calls for an under-10-hp outboard.



Chrysler's Bass Runner 15 carries a 55-hp Chrysler outboard. Narrow-beam cathedral hull is stable, yet efficient, design.

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OFFSHORE FISHERMEN The lions of the outboard fleet—rakish design, rugged construction, competence in big water. Most have wide-open cockpits and center-console steering stations, and they're fun to operate. They are designed to go offshore in the Great Lakes, the oceans, or the Gulf, and to come home again safely even if the weather kicks up. Twin-engine installations are popular for double dependability. And husky power plants are the rule rather than the exception. Mercury engineers regard minimum equipment for *open-water* boating as a boat of 16-17 feet, with 50 or 60 horsepower. Add some to that for real off-shore operation, and consider seriously doing it with two motors for safety and reliability.

A beautiful Mako, powered by a 135-horse Evinrude with a six-hp trolling motor alongside, make a reliable combination that's reasonably priced, well-suited to the job.

Twin 65 Johnsons on the 19-foot Roballo would use about 14 gph at top speed of 37 mph, half that at cruising speed.

Evinrude 65s on this big Mako 22 cost about $1260 and weigh slightly over 200 pounds each. Boat capacity includes motor weight.

MFG's Fishin' Caprice, 18 feet long, is rated for 160 hp maximum. A Merc 1500 would add 273 pounds, but give you a fast rig.

CRUISERS These will carry some of the comforts of home out to sea and to far-off vacations. They are well designed for family use. Comfortable weekenders come as small as 22 feet, either stern drive or outboard, and can be trailed without great difficulty. Yet they have berths, a galley, and even a private head. Great for all-day use, they give you and the family a place to get out of the sun and rain, to take a nap, and generally relax. With a little more length, you gain a lot more living space aboard. Prices range from $6-7000 up. You can buy a good 25-foot cruiser for as little as $10,000, complete with power plant. Consider carefully what you need. Cruiser design covers a wide field.

Compact, easy-to-trailer boat from Cruisers, Inc., has a single OMC stern drive that gives her plenty of speed, yet leaves her relatively easy to launch and recover.

Power options for the 21-foot MFG EZ Cruiser include a 165- or 225-hp OMC, a 165- or 188-hp Mercruiser stern drive.

Christ-Craft's 25-foot Express Cruiser, a four-sleeper, sells for $8750. She has a 200-hp CC inboard engine. **[Continued]**

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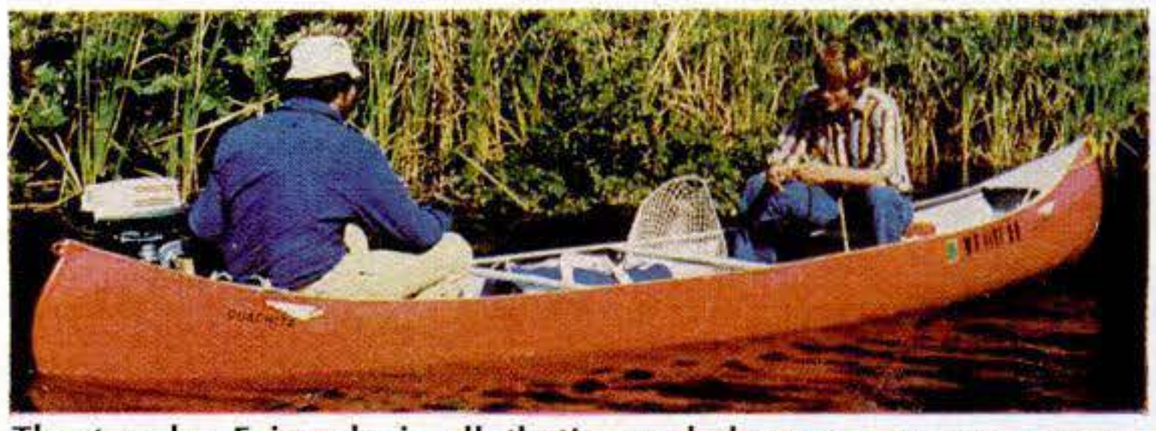
Pontoon-boat deluxe is Kayot's Executive. It's powered by a Chrysler 70 outboard (maximum rating is 85 hp), and sleeps five.

Big houseboats give the most living space for the length. Single stern drive, as on this Kayot, is okay for protected waters.

SPECIAL-PURPOSE BOATS Boats come in a delightful variety. If you want one that you can carry in your car trunk, buy an inflatable. If you want a sea-going house, there are many from which to choose. And the canoe remains one of the most beautiful—and useful—boats ever designed by man. Tailor the power to your own selection: one or two horsepower for the canoes, to mighty twin installations on the big houseboats. For smaller boats, the power plant's portability is a prime consideration. You can lift motors up to about 20 horsepower—85-90 pounds; bigger ones require a hoist for handling.



The two-hp Evinrude is all that's needed on a two-man canoe. Motor weighs only 24 pounds, costs $180; the canoe, about $250.

Small O'Day sailboat moves well in wind, but to return to dock in a calm, or for maneuvering, lightweight Evinrude 2 does it.

For a somewhat heavier overnighter, such as this Irwin sloop, the 7.5 Mercury outboard will do all that's required of it.

Zodiak inflatable can be stored in a closet, carried like a suitcase. Sizes, nine to 19 feet; power, four to nine hp.

Not all outboards play their life away. The 40-horse Evinrude (mounted in a well, forward) powers a broad-beamed clam boat.

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JETS AND SPEEDBOATS Are you a racing driver at heart? These three likeable hot-rods are representative of a whole family of needle-nose speedsters. Some are powered by outboards, some by big stern-drive plants, and many 1973 speedboats have high-powered, easy-to-handle jet-pump drives. Some things they all have in common: plenty of thrills and spray, and a lot of horsepower for the boat—power to burn. In this kind of boat you want all the horsepower the boat's rating will allow, because your objective is just the most speed you can get out of that hull. Make sure you know how to handle one of these babies before you open the throttle. Power covers a fantastic range upward, and is scaled to push hell out of the boat. You count the gas tickets later.

The small 13-foot Checkmate will hit 60 mph with the Evinrude 65 behind. Better wear a helmet and racing-type life vest at these speeds; you'll look good, too.

Chrysler's great Conqueror, a delta-wing speedster powered by Chrysler's 130-hp outboard, is as fast as she looks. Yet there's plenty of room for four aboard—in padded comfort. She's 16 feet, has a shallow V hull.

Glastron's CV-21 with 455 Berkeley jet is designed for speeds of 52-54 mph. She costs just under $8000, is a great ski boat, and handles like a lover!

OUTBOARD POWER: MATCH YOUR BOAT AND MOTOR HERE

1973 HORSEPOWER							
Chrysler	3.6 6 8	9.9 12.9 20	25 30 35	45 55	70 85	105 120 130	150*
Evinrude	2 4 6	9.5 18	25	40 50	65 85	115 135	Super Strangler* (150-hp plus)
Johnson	2 4 6	9.5 18	25	40 50	65 85	115 135	Stinger GP* (150-hp plus)
Mercury	4 7.5	9.8 20		40 50	65 85	115 150	Twister II*
Sears	3 4.5 5.5 7.5	9.9 15					
WHAT IT COSTS: (Approx. retail prices)	$104 to $145	$429 to $588	$615 to $715	$750 to $1095	$1262 to $1493	$1550 to $2395	About $2800
WHAT IT WEIGHS: (Carry to the boat, or mount with a crane?)	24 to 71 lbs.	56 to 96 lbs.	85 to 127 lbs.	128 to 173 lbs.	201 to 262 lbs.	223 to 273 lbs.	About 270 lbs.
WHAT IT BURNS: (Approx. gal. per hr. at speed—less at cruise)	"A quart a day" to about 1½ g.p.h.	1½ to 2½ g.p.h.	2¾ to 4½ g.p.h.	4½ to 5½ g.p.h.	7 to 10 g.p.h.	10½ to 13½ g.p.h.	14 to 18 g.p.h.
WHAT IT DOES: (Best applications)	Canoes Small fishing boats Sailboat auxiliaries Dinghies and prams	Small fishing boats Inflatables Sailboat auxiliaries Dinghies and prams	Fishing boats Light ski boats Special-purpose boats	Ski boats and and runabouts Offshore fishing boats and cruisers (twin installations) Bass boats	Runabouts Outboard cruisers Ski boats Offshore fishing boats	Offshore fishing boats Big runabouts Outboard cruisers Semipro racing	Semipro and professional racing *Limited-production racing engines

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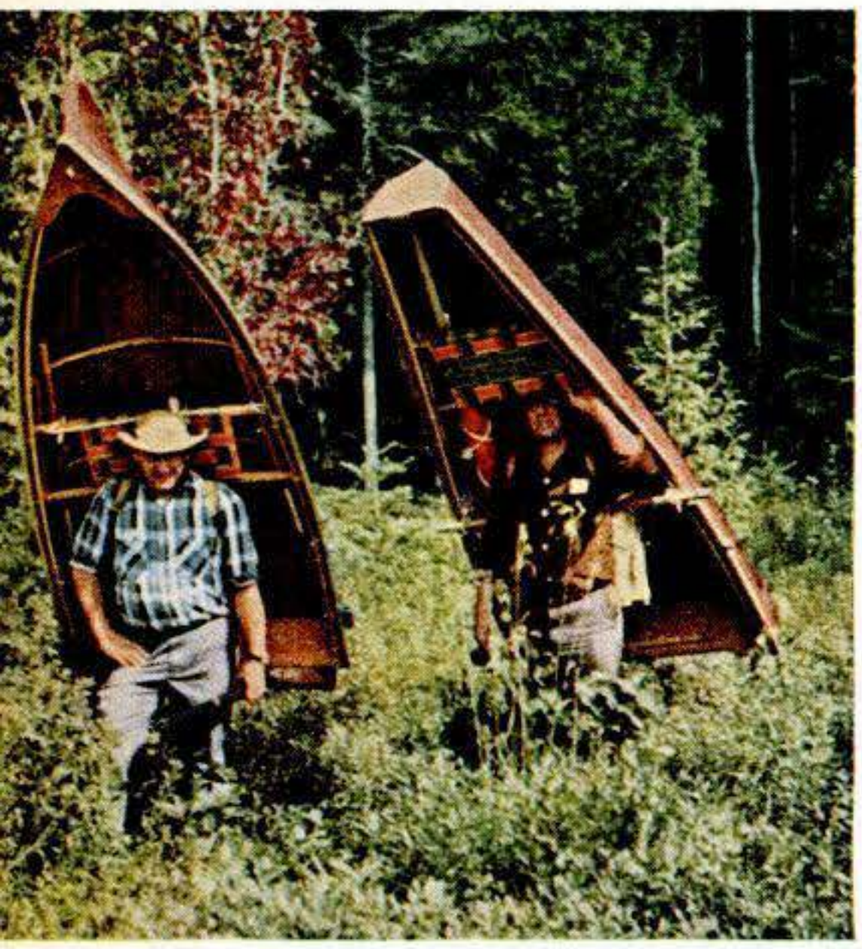
How to Build a Wood-Strip TRAIL BOAT



Two sections can be backpacked, even though bulky. On trail, each section can serve as a lean-to shelter for one man.

Transport is easy atop car, with equipment stored under boat. Or separated boat sections can be hauled inside a station wagon.

One man alone can row or paddle the front eight-footer. It's possible to Indian-paddle the rear section (bottom), but it's less stable.

It splits across the middle for portage. And you can row, paddle, power, or sail it

By JACK PAYNE
and TOM McCONAGHIE

Our Trail Boat had its origins in the famous Adirondack guide boat—a sturdy rowboat that one man could portage over tough mountain trails. The Trail Boat divides in half across the middle so two fishing, hunting, or camping partners can each tote a share.

Although it's primarily for rowing, you can paddle the boat as easily as a canoe, sail it with an auxiliary sprit rig, or power it with a fishing outboard. The joined hull measures 16′ and weighs 89 pounds. The front half can be rowed or paddled as a separate eight-footer. Even the stern section is usable alone in a pinch.

We previewed our boat this past fall on a pack trip through the Adirondacks—the heart of guide-boat country. Everyone we met—experienced native and green tourist alike—went ape for it.

You build the boat easily, using modern materials and a time-tested hull-building method: the wood-strip procedure first presented to POPULAR SCIENCE readers for the Redwood Canoe [March '67] and used more recently for our Pumpkin Seed Sailboat [May '72, p. 154]. For the Trail Boat, you first laminate ribs around formers and then lay up longitudinal strips on the ribs.

The building frame. It's made of two-by-fours. Take time to lay it out accurately and square. Level it end to end as well as sideways. Mark a centerline on each frame crossmember, using a string stretched from a center on each end member.

Cut the two #5 formers, the transom, stern and stem pieces—they remain in the finished boat—from ½″ exterior-grade or marine plywood. Other formers may be plyscore. As each former is drawn on the plywood be sure to mark a vertical centerline on each, as well as a horizontal base line.

Nail each station former to its frame with the centerlines together and the horizonal line on the former extension along the top of the frame two-by-four. Check each one with a square to be sure it's perpendicular to the building frame. Separate the two #5 formers with 1/16″ strips of wood—the width of a saber-saw blade—for later cutting.

Ribs. After all formers are in place, laminate ribs on each one, using strips of oak, birch, maple, or other hardwood. Start at either end of the hull with a former that does not have a plywood piece as part of the rib.

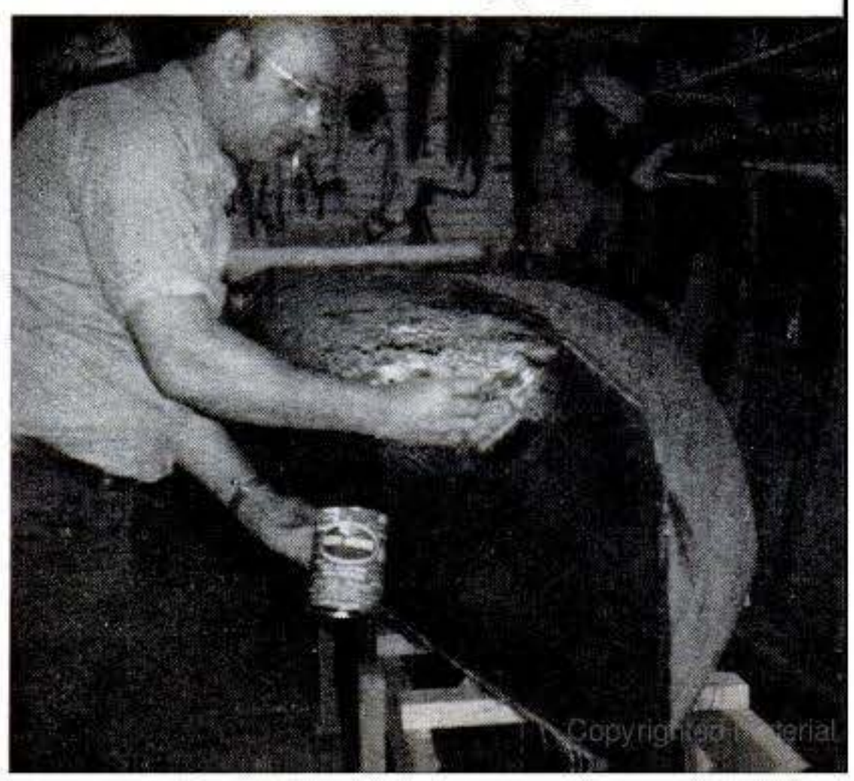
Glue eight rib strips on the former. Using a 1/16″ drill, drill straight down through the strips and about 1/16″ into the former at its exact center. Drive a 1¼″ #16 nail through the hole into the former. Drill similar nail holes every 8″ through the ribs. *Note:* These nails must be pulled out when

[Continued on page 146]

For boat drawings, turn the page

Laminate a rib around each former, using eight 5′-long, 1/16″-by-½″ hardwood strips per rib. Put waterproof glue on ½″ faces and bend strips, nailing in drilled holes.

Glass the hull one side at a time. Apply heavy resin coat and work it through cloth, brushing out well as shown. With one side finished, do second, overlapping cloth 2″.



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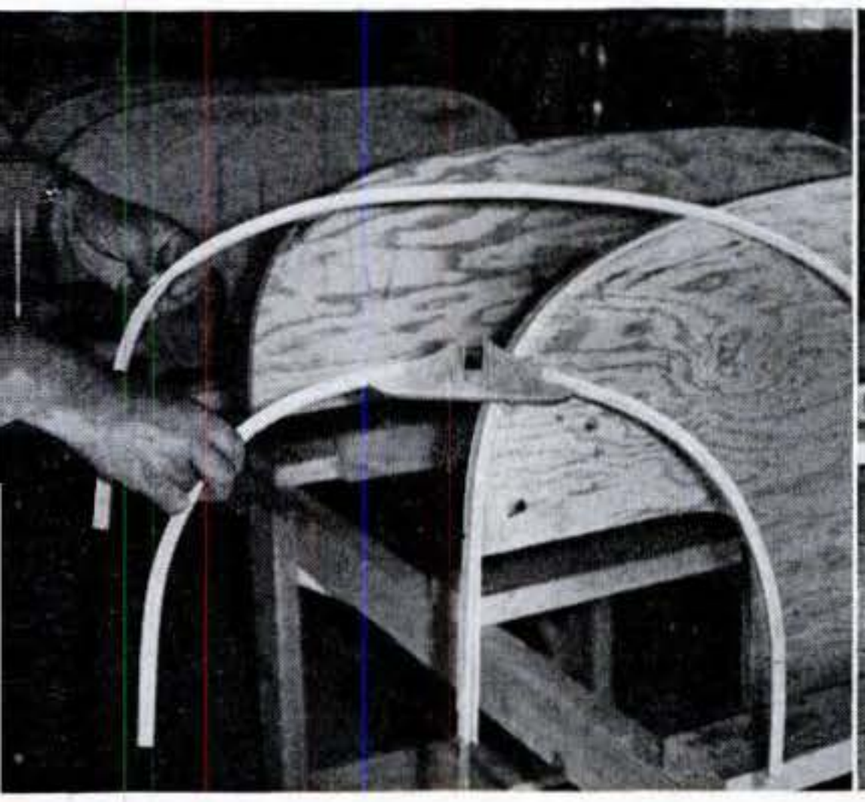
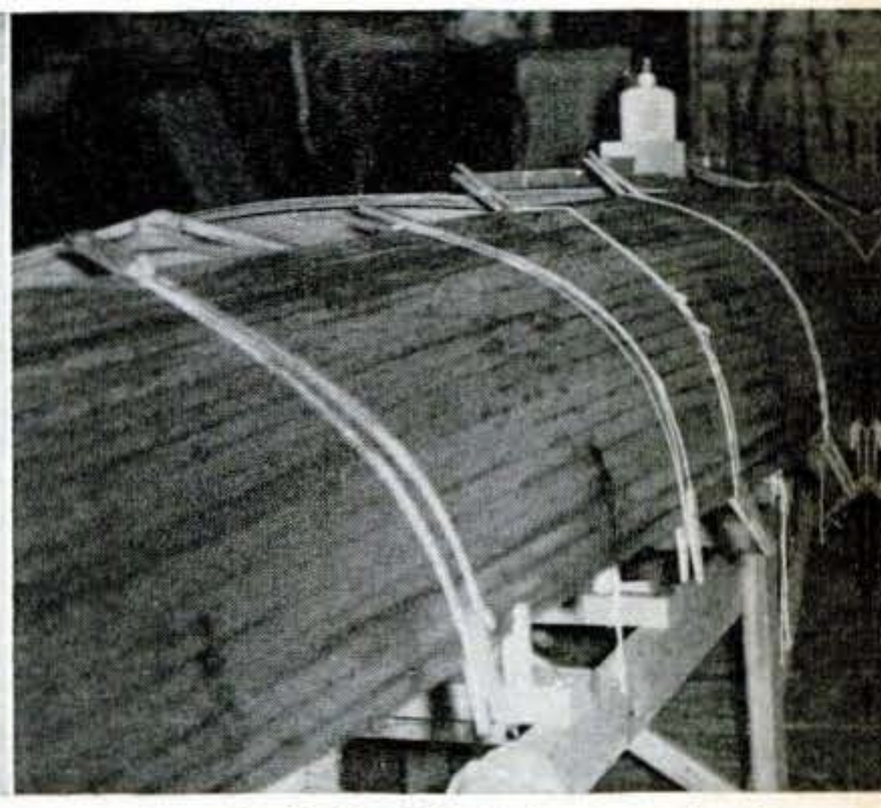
Three metal clamps keep the halves securely together while you're using the boat as a single unit. Boat has three seats, a beam of 40".



Remove ribs after glue has set by pulling out retaining nails. Sand top and bottom rib surfaces and round off what will be the upper faces of rib in finished canoe.

Lay up wood strips as if you were building single hull. Separate two #5 formers with 1/16" wood. As each wood strip is applied, extend pencil mark (above) as sawing guide.

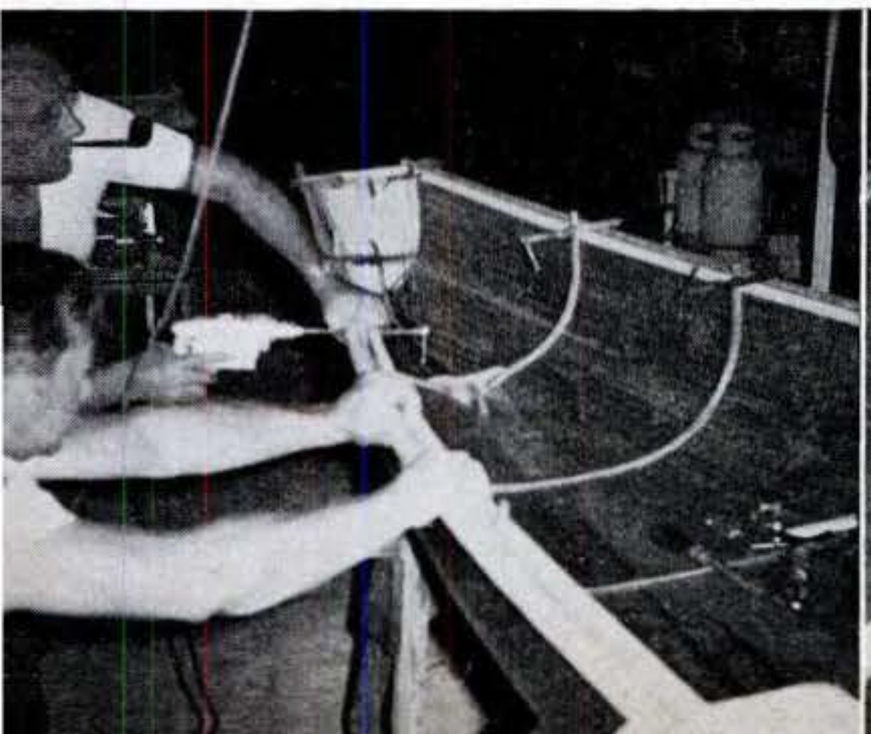


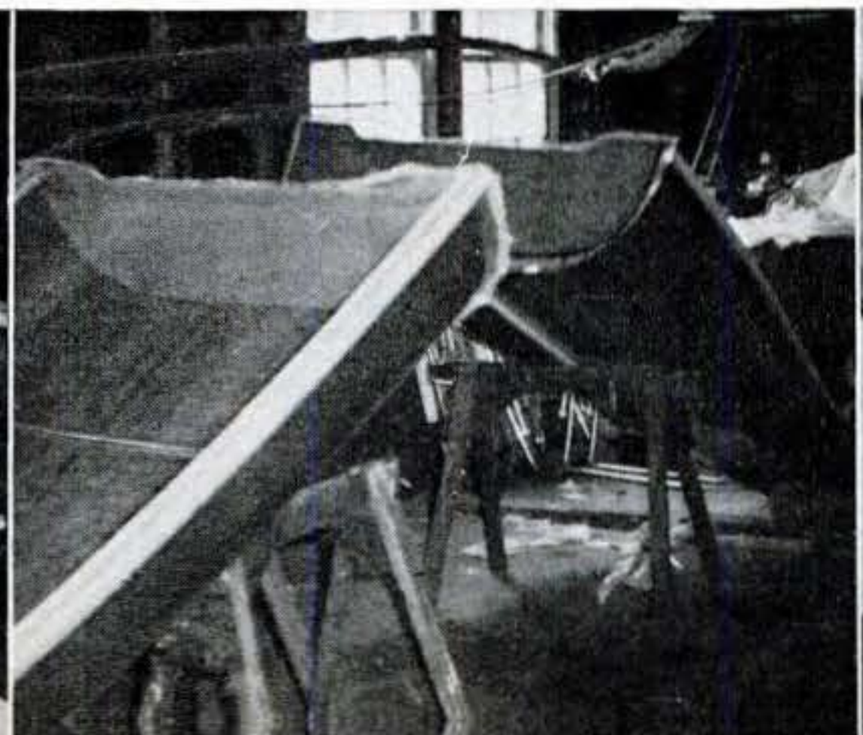
View of nearly finished hull shows method used to clamp wood strips until the glue sets—spring-type clothes pins at the top and bottom, with rubber bands between.

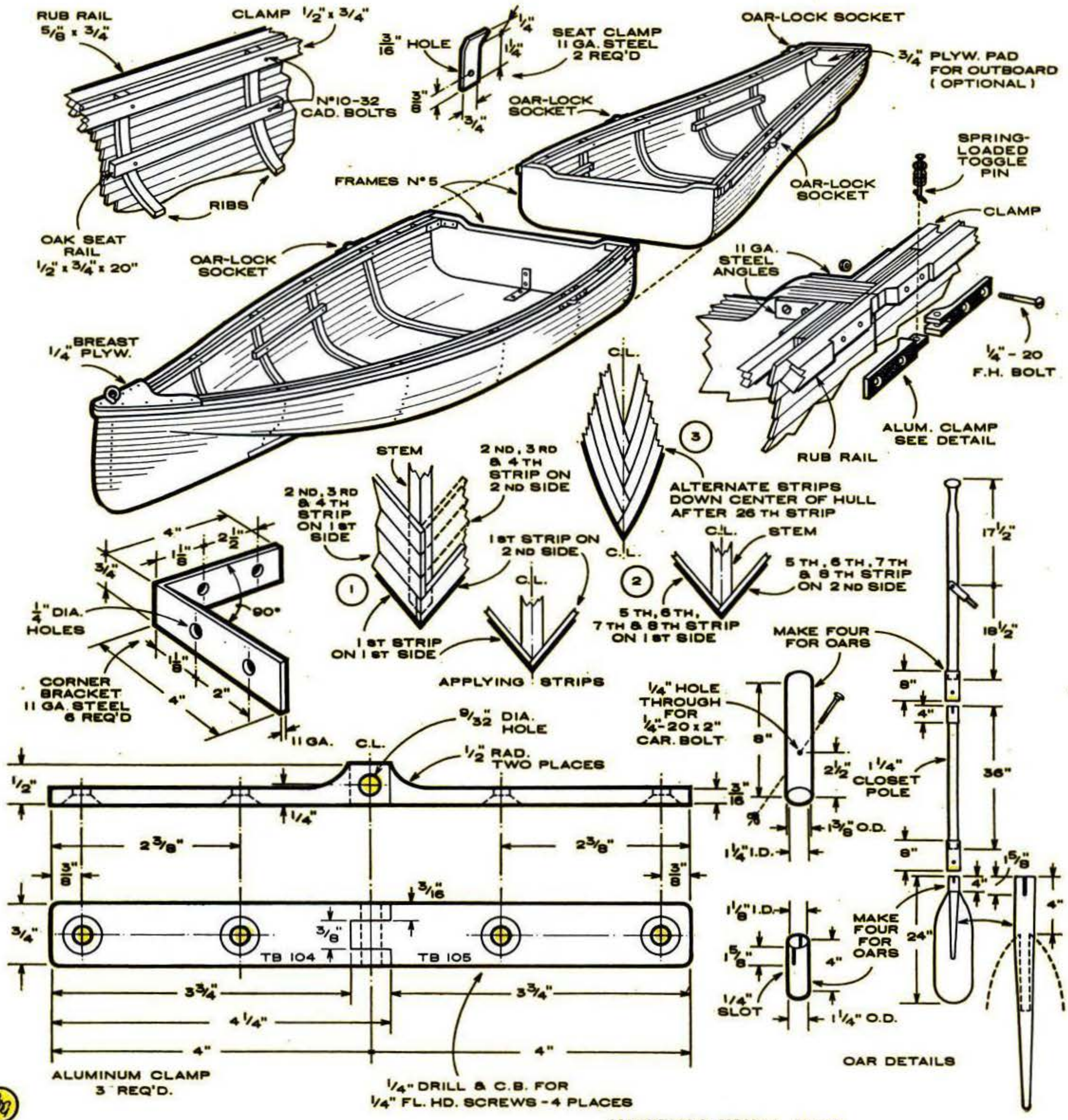
It takes two to secure rub rail and its accompanying clamp strip on each side of boat. Clamp strip goes on inner edge of each rib at top, the rub rail on outside.

Saw top edges of #5 formers to shape after hull is divided. Sand protruding planking strips. Lay cloth on outside of each #5 and coat with resin. Sand smooth when dry.

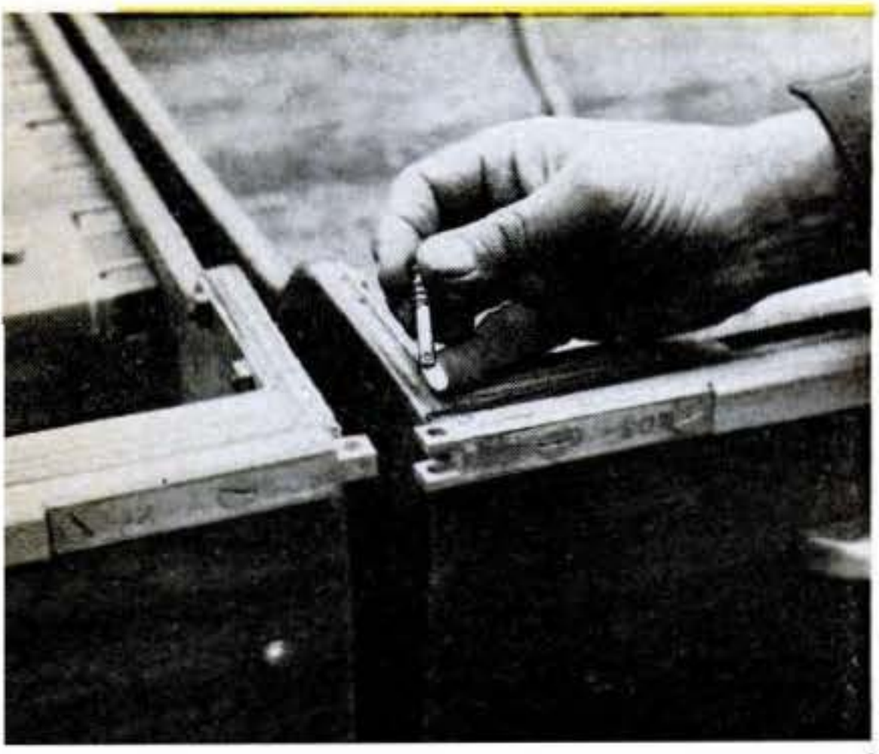
Staple ends of lawn-chair webbing inside oak seat frames. Assemble the frames with corner angles to dimensions in drawings. Bolt only front and rear seats in place.







Aluminum clamps with latch pins hold boat sections together. One clamp (below) is located on outer edge of each rub rail; the third is notched into keel.



MATERIALS YOU'LL NEED

WOOD			12	1/4"-20x1"	Cad.-plated FH bolts
4 pc.	2x4x16'	Fir (frame)	2	10-32x2"	Cad.-plated FH bolts
1 pc.	1/2"4'x8'	Plycore (formers)	1 lb.	16d	Common nails (formers to frame)
1 pc.	1/2"4'x8'	A.C. Ext. plywood (#5 formers, stems, etc.)	12	1"	Corner brackets (seats)
3 pc.	1x10x18'	Redwood (strips)	2	1/8"x3/4"x30"	Steel bar stock (corner braces)
1 pc.	1/2"x6"x5'	Oak or mahog. (ribs)	2 bx.	1 1/4" #16	Nails (ribs)
1 pc.	1/2"x6"x5'	Birch or maple (ribs)	1	3/4"x8'	Alum. tubing (stick)
1 pc.	1x5x18'	Maple, oak, or mahogany (keel, rub rail, clamps)	2	large bottles	White glue (for clamping)
2	1 1/4" dia.x8'	Closet poles (oars/paddles)	1	large can	Resorcinol glue
HARDWARE (local)			60'		Lawn-chair webbing
15	3/4" #10	Cad.-plated screws	**HARDWARE (marine)**		
2	1 1/4" #10	Cad.-plated screws	5—oarlock socket ; 2—North River-type oarlocks; 1—1/4" x 2" eyebolt; 800—3/4" #15 bronze boat nails; 15 yds.—Vectra cloth or fiberglass; 12 qts.—Boat Armor iso resin; 6 pc.—1/2" x 3/4" x 4 1/4" alum. bar stock (hull clamps)		
2	1 3/4" #8	Cad.-plated screws			
36	#10-24x2"	Cad.-plated FH machine screws			
36	#10-24	Cad.-plated hex nuts			
8	1/4"-20x2 1/2"	Cad.-plated FH bolts			
10	1/4"-20x2"	Cad.-plated FH bolts	Note: Three sets of hull clamps with toggle pins are $12 ppd. from Pond Brook Products, Box 301, Franklin Lakes, N.J. 07417.		
4	1/4"-20x1 1/2"	Cad.-plated FH bolts			

Ordering plans and templates

If you like plans larger than those printed here, send $2.95 for Trail Boat Plan 5558, which also includes additional procedural details. Full-size cardboard templates for formers and other parts are available (U.S. and territories only) for $5; order Trail Boat Templates 5559. Send check or money order to PS Plans Div., 355 Lexington Ave., N.Y., N.Y. 10017.

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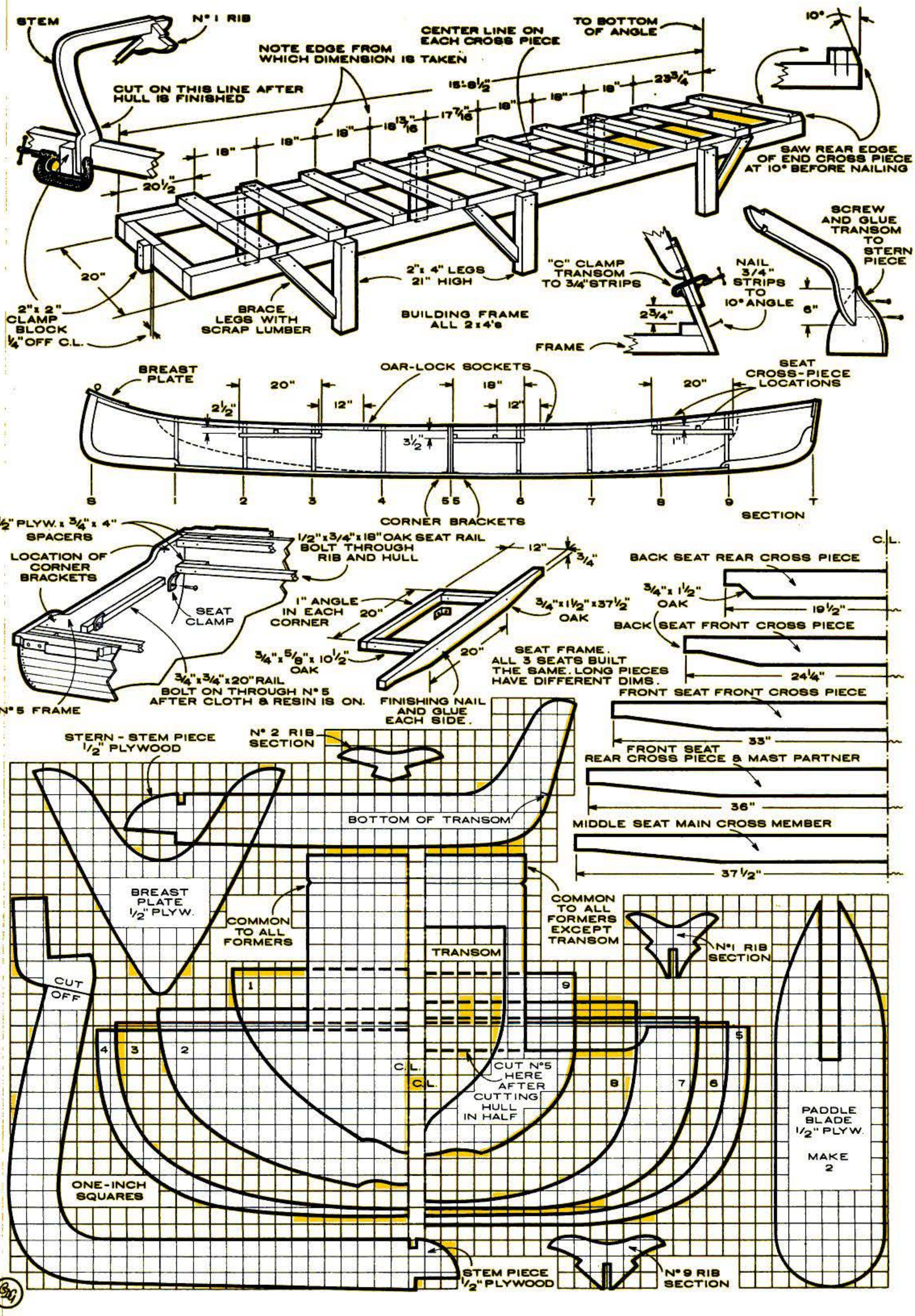

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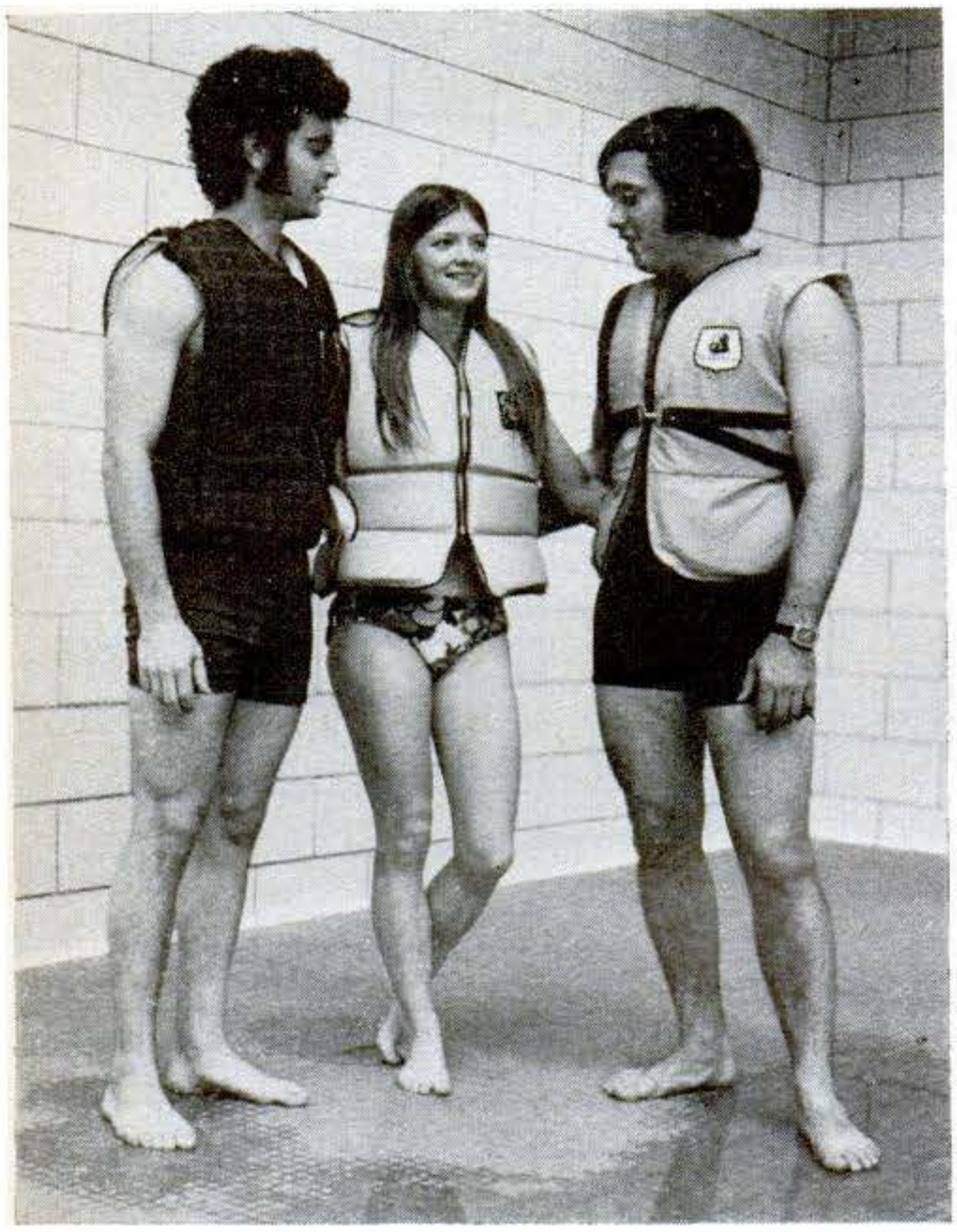
New Coast Guard regulations coming up:

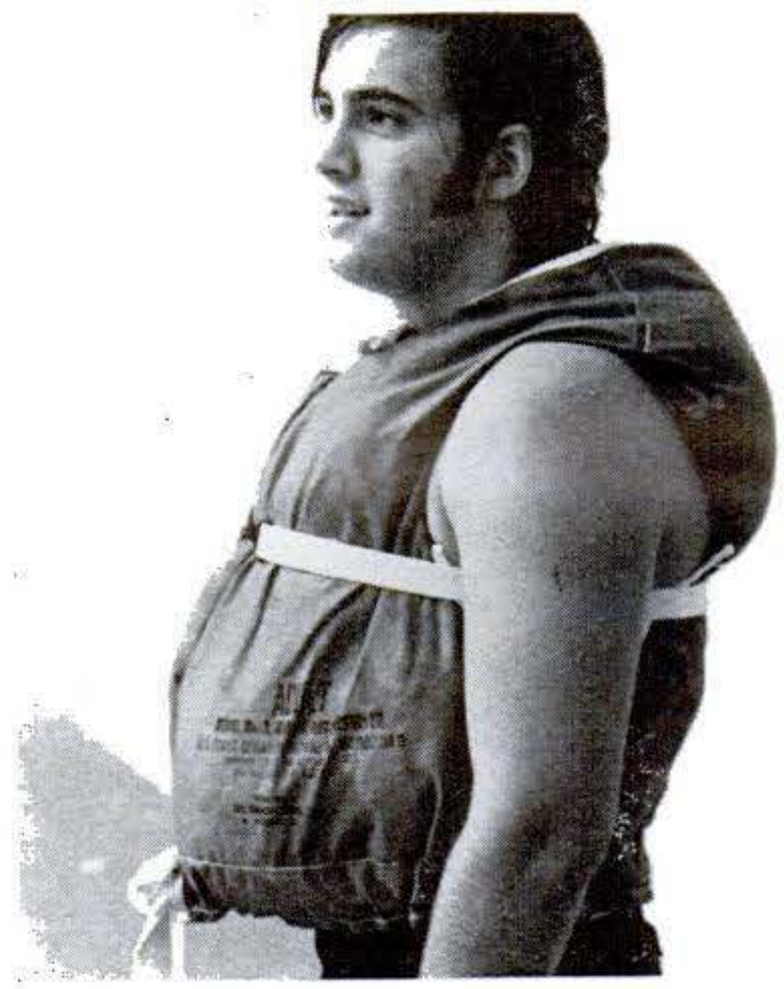
A Life-Saving Guide to Life Jackets

TYPE I device is the life preserver, like Ero's kapok type. It provides maximum buoyancy; rights you if unconscious. Life preservers are approved for all recreational boats and commercial vessels.



You can spend as little as $4 or as much as $66 for a personal flotation device. Here's how to choose the best for your boating needs

By DOUG GARR



CG-approved vests are comfortable and come in different styles. From left: Stearns' San Souci sailing vest and Canoe-Kayak vest (each $24), Ero's Mariner with chest strap (about $20).

"Oh, I already know how to swim. I don't need a life preserver. Besides, I'd never wear one; they're too bulky and uncomfortable."

That's a typical reaction to life-saving devices from beginning or inexperienced boatsmen, according to the U.S. Coast Guard. Too often it results in tragedy. In 1971 nearly half the people that died in boating accidents in U.S. waters had access to a life preserver but did not use it or used it improperly.

What's your excuse? Actually, you don't have any. Since the Federal Boat Safety Act, effective in 1971, every recreational boat must carry at least one CG-approved flotation device for each person aboard. Three states (Texas, Utah, and Nebraska) have even passed laws that require children to *wear* them on boats.

But the Coast Guard doesn't recommend rushing out to the local marina and buying a life-saving device just because it's "CG-approved." Nor do they want to make it so confusing that you'll forget about wearing one.

In order to improve our boating safety record, the Coast Guard plans to update the life-jacket regulations again. The updating will make buying a flotation device easier and make using it safer.

When the new regulations take effect (the target date at press time was November 1, 1973), it means a reclassification of every type, to say more specifically which jackets are acceptable for which size boats. It also means that manufacturers must put new labels on them also, identifying their type and performance. (PFD, for Personal Flotation Device, is the official description; "life preserver" refers to only one type in a large family.)

How the new regs affect you. If your boat is under 16 feet, *any* CG-approved PFD will still be acceptable (except work vests used on commercial ships). If your boat is over 16 feet, cushions and other throwable devices will no longer fill the requirement; you'll need wearable PFD's only. And if your boat is still bigger—over 26 feet—you must have at least one throwable device *in addition* to one PFD available for each person aboard. (There will be two exceptions to all the new regulations: some models of canoes and kayaks. Also, the boat lengths are not yet final.)

Some parts of the law are tougher. An off-shore sailboat under 40 feet will not be allowed to carry only

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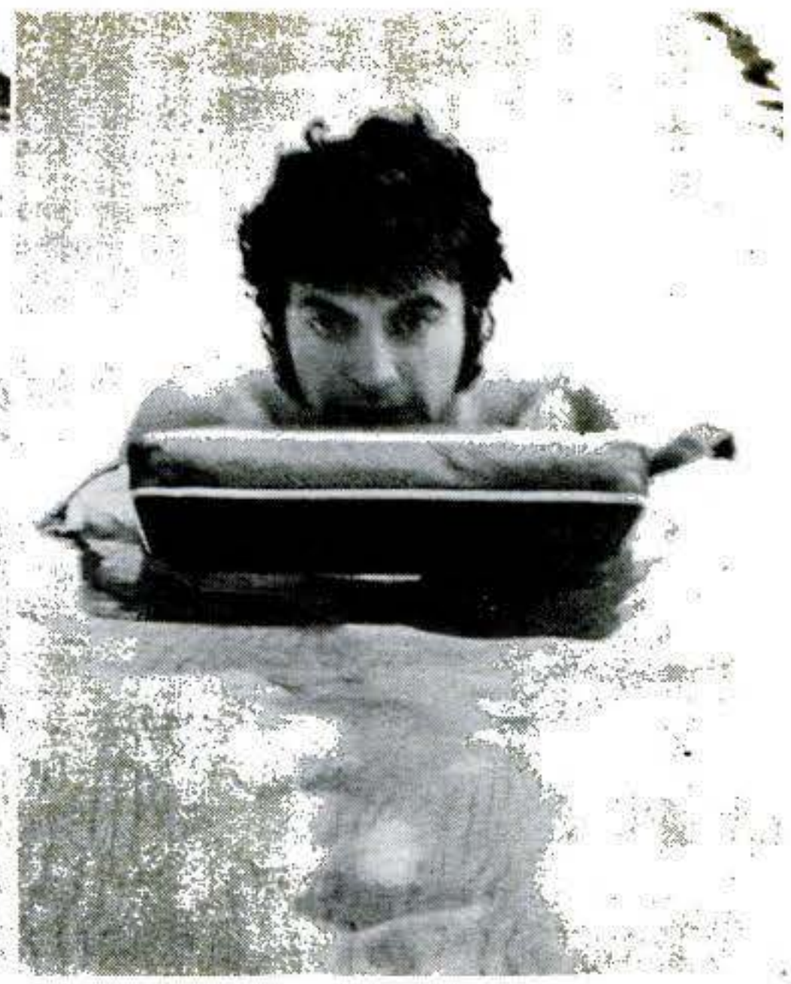
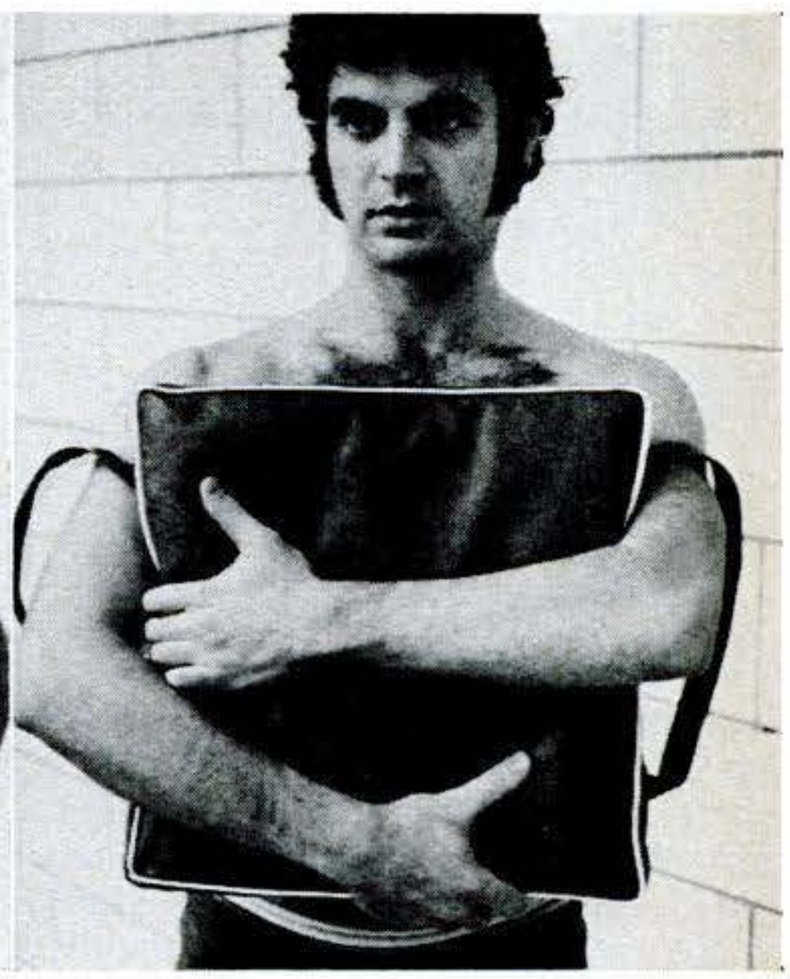
TYPE II device is the buoyant vest. It has a little less buoyancy and takes slightly longer to right unconscious wearer. Smaller and more comfortable than life preservers, it is the least expensive of the wearable types.

TYPE III device, like Stearns' vest, is comfortable to wear but most expensive. These special purpose devices will float you face up but may not turn you upright if unconscious. Type III also includes flotation jackets and coats.



TYPE IV device, like cushion from Atlantic and Pacific, is only type that is not wearable. Type IV include ring buoys and horseshoes. Correct way to use cushion is shown above, never wear on back.



buoyant cushions, illogically permitted under the present law.

Other parts are more flexible. If you own a 40-foot houseboat and rarely leave your mooring, you'll be able to use special-purpose PFD's. Right now, you can't.

In order to get acquainted with the various types of PFD's and to get the latest word on the new law, I talked with Coast Guard boating safety experts in Washington. And then I spent a day jumping into the water with more than a dozen jackets, vests, belts, and coats.

Admittedly, it seems impossible to figure out what's best for your own boating situation at first, but after doing a little homework, it's not hard.

Capt. Vincent Mitchell of the Coast Guard's Office of Boating Safety sums it up: "Before you go shopping, think about the type of boat you own, the waters you'll be operating in, and the people you'll be having aboard."

Let's take a look at the four types of PFD's that are approved:

Type I—life preservers. These are the large jackets you see on ships. They must be international-orange-colored, and reversible—you can even wear them the "wrong" way. They have two important characteristics: maximum buoyancy and maximum "positive righting moment." This expression means that it will turn you face up in about five seconds if you're unconscious. They're fairly expensive (between $14-$20), cumbersome, and uncomfortable to wear. But life preservers are the best PFD's for hazardous boating conditions.

Type II—buoyant vests. They're somewhat like life preservers, but have a little less buoyancy and a little less righting ability. They're a little more comforable to wear, cheaper (between $4-$10, although some are as high as $20), and a little smaller. They're probably the best choice for offshore boating; and they're convenient for your kids.

If you're navigating in very cold waters—say, during the winter off Nantucket—you should have a life preserver or buoyant vest. Reason? Your expected survival time decreases with the temperature of the water. "You won't last long in frigid waters with only a buoyant cushion," says Capt. J. W. Hume of the Coast Guard. In water just above freezing you'll lose consciousness in 15 minutes.

Type III—special purpose. But if you're like the majority of the na-

Continued

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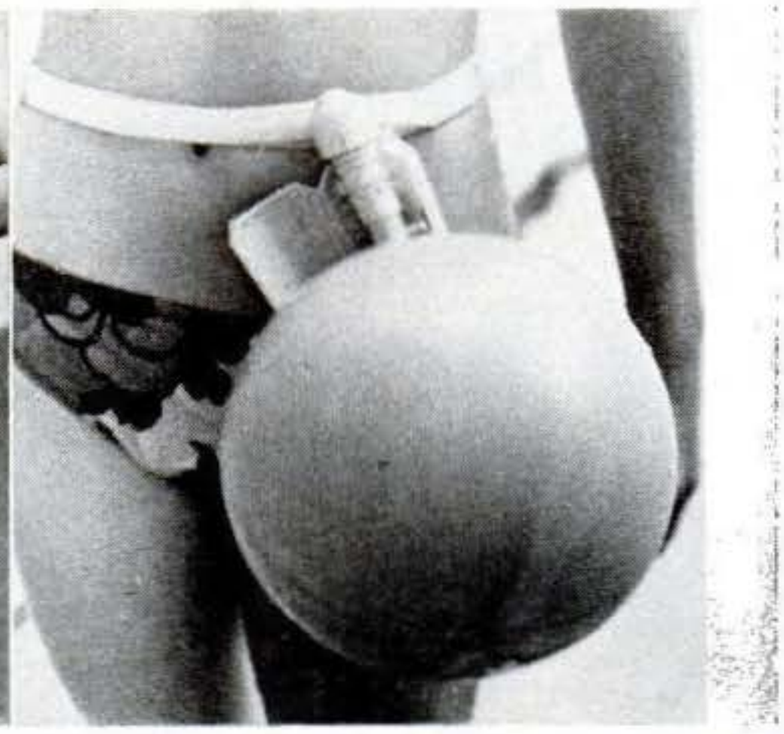
Yachtsman's double-breasted blazer ($66) from Stearns (left) and Mariner jacket ($44) from Empress are CG-approved type III's.

Empress' Mariner jacket provides wearer with excellent flotation. Sewn inside coat is closed-cell plastic foam.

Ski belt from Atlantic and Pacific (left) and automatic inflatable from Gladding are not CG-approved. None like them are.



Gladding's inflatable has CO_2 cartridge that fills balloon-type device when wearer enters the water. It costs $8, is re-usable.

tion's seafarers, you probably never venture farther than a few miles from the dock during the summer. That's where the versatile Type III special-purpose PFD's come in. They're vests and jackets and come in all kinds of colors and sizes. Unquestionably, they're the most comfortable to wear. I found them easiest to swim with, too. Two drawbacks, however: First, they're very expensive. Vests usually cost between $18-$30; coats, $45-$55. And while type III jackets have as much buoyancy as the buoyant vests, they may not turn you face-up if you're unconscious.

Uses for special-purpose devices? You can get a camouflaged vest for hunting, long-sleeve coats for winter sailing, short-sleeve vests for summer sailing, and jump jackets for water skiing. (Jump jackets are CG-approved; ski belts aren't.) There's even a stylish plaid vest for gals, and a double-breasted coat for discriminating sailors. By far, these are for the boatsman who hates to wear a PFD.

Type IV—throwables. The last type is easily distinguished from the others because they're not meant to be worn, but to be thrown to someone who accidentally goes overboard. Type IV PFD's include rings, cushions, and horseshoes. They have more buoyancy than buoyant vests and special-purpose devices but less than life preservers.

Advantages? The cushions are cheap (about $5), do double duty as seats, and are always around when you need them (if you're sitting on them). Ring buoys and horseshoes are designed for on-deck accessibility. They cost anywhere from $8 to $45, depending on the material.

Disadvantages with the throwable PFD's? You can't wear them, obviously. If you're in the water for an extended period, they're not as practical as the other types that are made to "float the wearer indefinitely."

Okay, let's say you've decided to buy a wearable PFD, and you've picked out the type that best suits your boating needs. What about the material? Basically, the choice narrows down to plastic foam (commonly PVC) or kapok. (You may find some types made of cork, fiberglass, or balsa wood, but they're uncommon.)

Kapok PFD's contain sealed pockets with a special fiber from trees that is excellent for flotation. These jackets feel something like a feather-filled pillow. They're not as durable as PVC plastic types but are much softer on the skin and more comfortable. Plan on spending about twice as much for plastic PFD's as for kapok types. PVC types are best for frequent in-water use because they dry faster.

If you decide on PVC, you'll have still another choice: canvas covered or noncovered. Noncovered plastic is used for jump jackets and ski belts. Canvas-covered PVC types are used mainly for sailing and hunting and fishing vests.

Consider your size carefully. Most life preservers and buoyant vests are labeled "adult" (for anyone weighing over 90 pounds), "child" (for supporting 50 to 90 pounds), and "small child" (for tots under 50 pounds). Although it's hard to fake unconsciousness, some Type I's and II's turned me face-up faster than they did a friend of nearly the same weight. That's because everyone's buoyancy requirements are slightly different. Generally, fat people float better than skinny people. Your own buoyancy requirements may change as your physical makeup changes. Even the amount or type of clothes you wear will affect how you float, and ultimately, how a PFD will perform on you.

Although your PFD doesn't have to fit like a tailored suit, it should fit like your seat belt—not too tight or too loose. A good fit is especially important with the special-purpose vests. CG Master Chief Kent Flowers says, "Make sure they're snug around the waist or you'll wind up with more flotation on your back than in the front. That may tend to put you face down."

Try it on—and try it out. How do you know what it will do for you? Capt. Mitchell advises: "Take it out of the plastic bag, adjust the straps, and try it out in shallow water. Get to know it. Have your kids try theirs, too. Have them practice putting it on in the dark, if necessary."

There are some fine PFD's that are not CG-approved, for several reasons. Foreign makers' vests aren't approved because they don't have a U.S. Coast Guard inspector at the factory. Provisions have been made, however, for future approval.

No inflatables now on the market are approved, for they're not puncture-proof. "Mae Wests" like those found on airplanes require special maintenance, too. Inflatables are fine as back-up lifesaving gear.

Ski belts aren't approved for two reasons: They don't have adequate buoyancy and righting ability.

[Continued on page 154]

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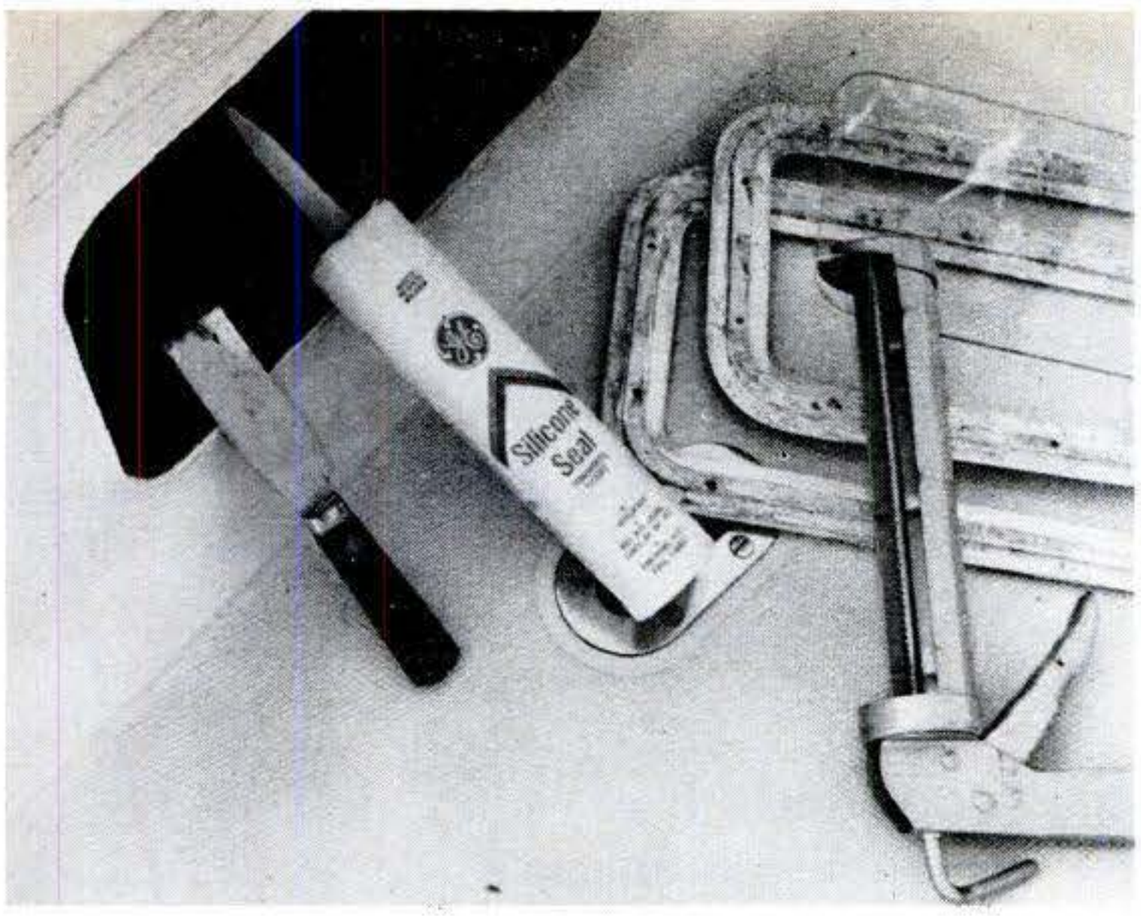
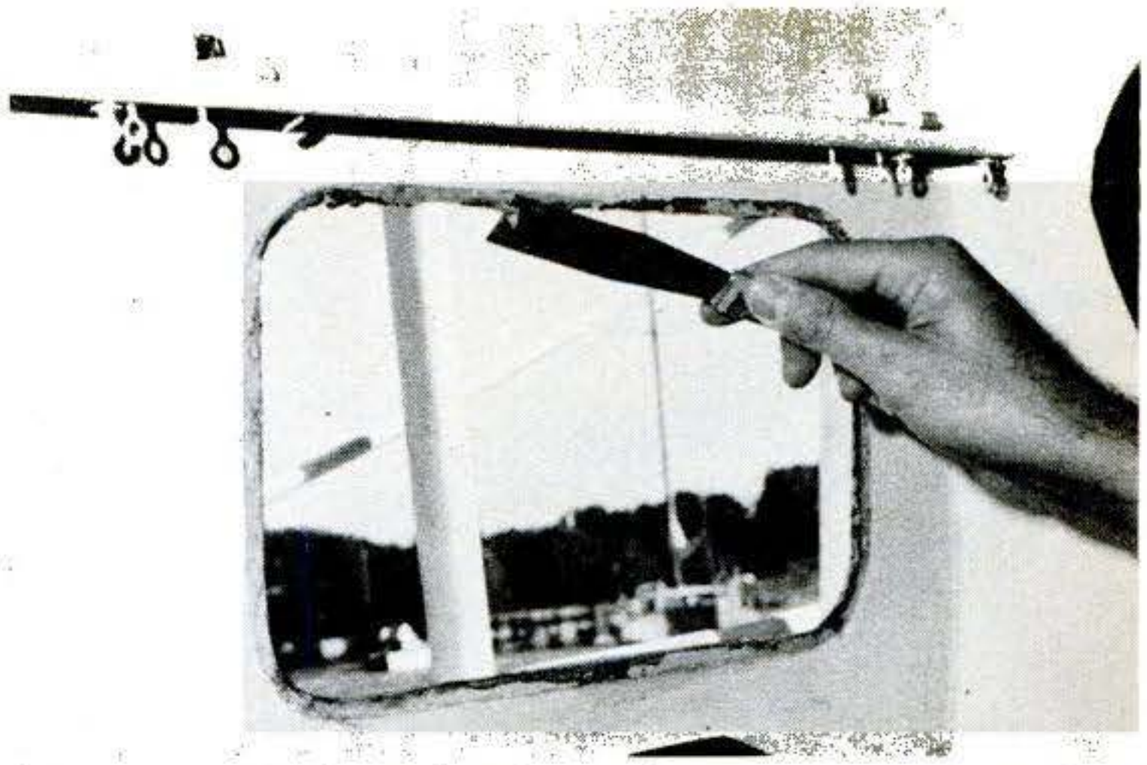
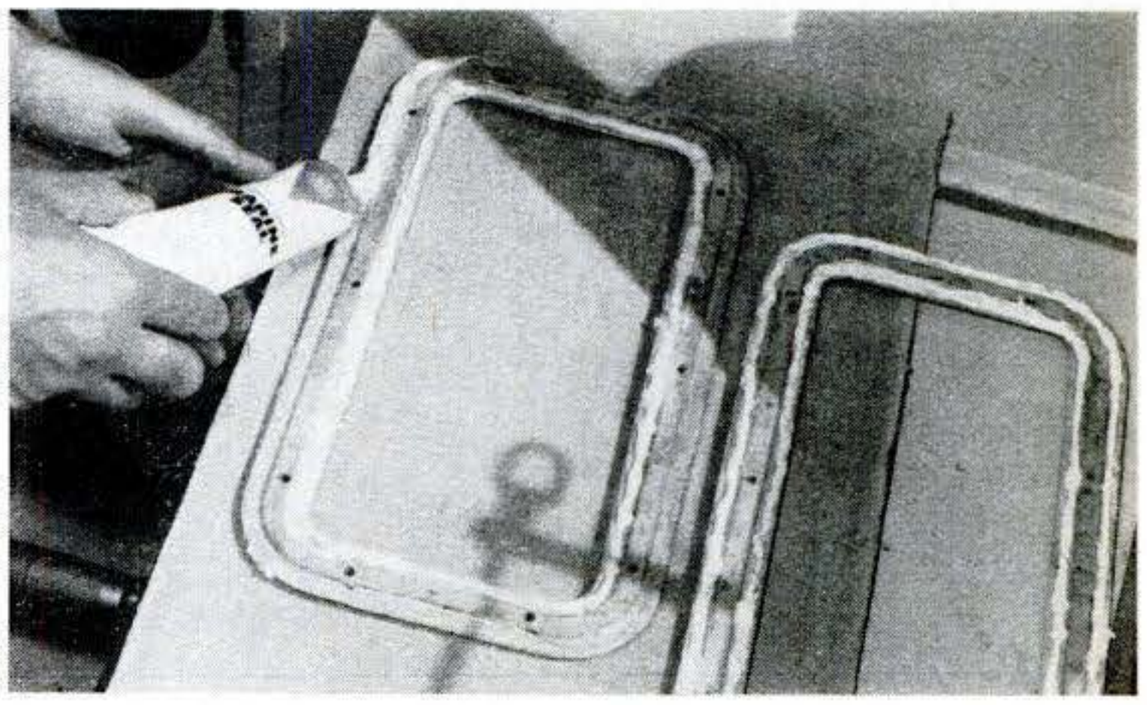




Remove two-part frame that clamps glass in opening. Scrape dried adhesive from edges both inside (above) and out (photo at left).

Scrape old sealant from frames, getting inside faces as clean and smooth as possible for a tight and lasting seal with new beads.



Apply double bead of sealant to each frame. Silicone seal comes in squeeze tube (above) or in cartridges for caulking guns.

1973 BOATING

Portlight Leaks? Seal 'Em Yourself

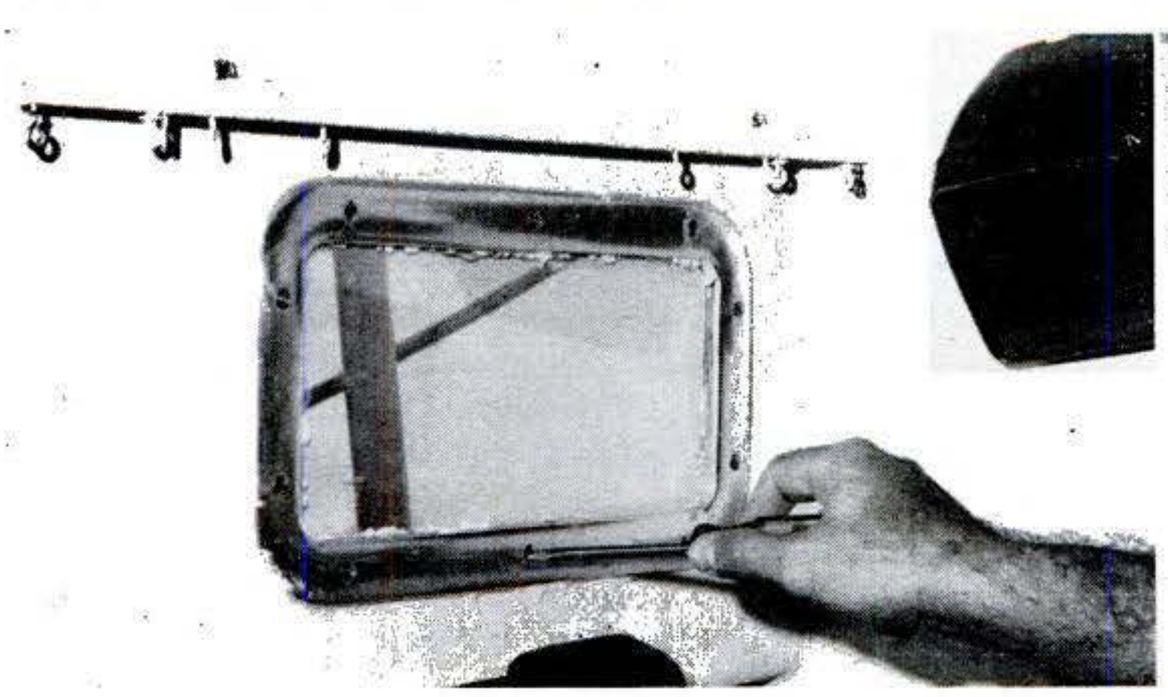
By MICHAEL ISSER

Readying your boat for the coming season? While you're cleaning, sanding, and painting, don't forget that portlight leak that annoyed you all last summer. There's no reason to live with it any longer—silicone seal makes a lasting repair quick and easy.

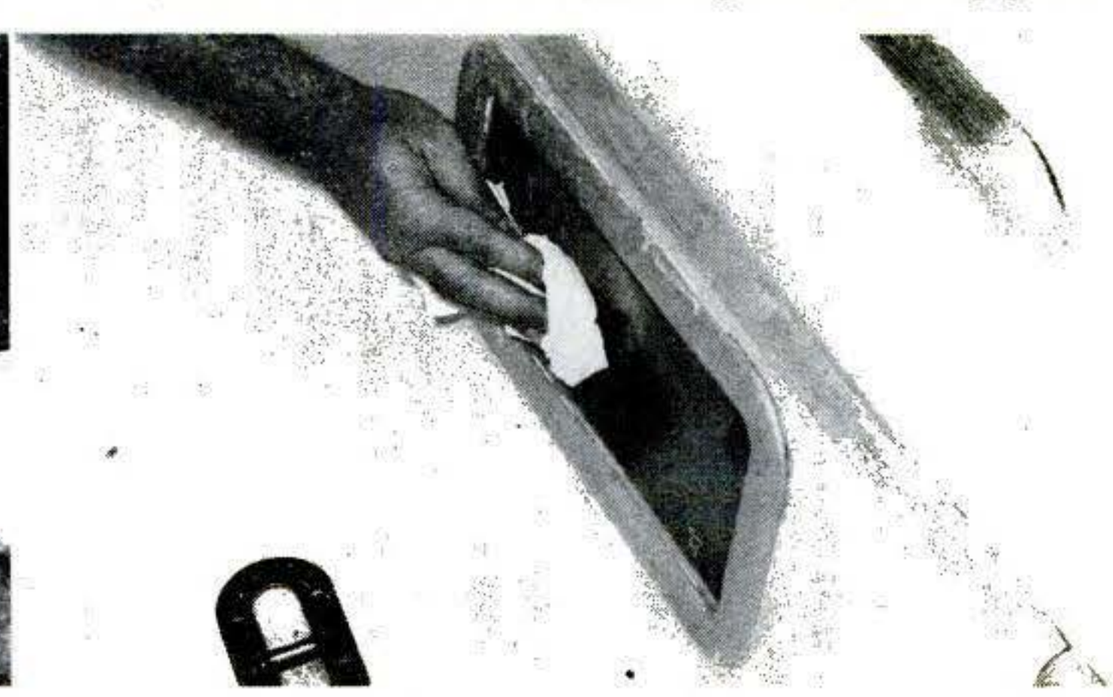
Most lights are held in the cabin wall by a two-part metal frame like the one shown in our photos. The screws that hold it together are easy to back off from inside the cabin. Then you can slip both the inside and outside frames and the glass from the opening.

The GE silicone we used is labeled Marine Seal when it's packaged in a squeeze tube for small jobs, as at right. Make certain the silicone beads are continuous, without skips; neatness doesn't count, though, since they'll be squashed flat in reassembly. Don't delay assembly after application or the bead will skin over.

And don't toss out the silicone that's left in the tube; it's a fine seal for galley sinks, a mender for canvas and rubber, a caulk for the hull and deck. PS



Fit reassembled window back into the opening and tighten the screws you removed earlier. Note squeeze-out of excess sealant.



Remove excess from glass, frames, and wall with wet cloth. After 24-hour cure, window is ready for rough water or a deluge.

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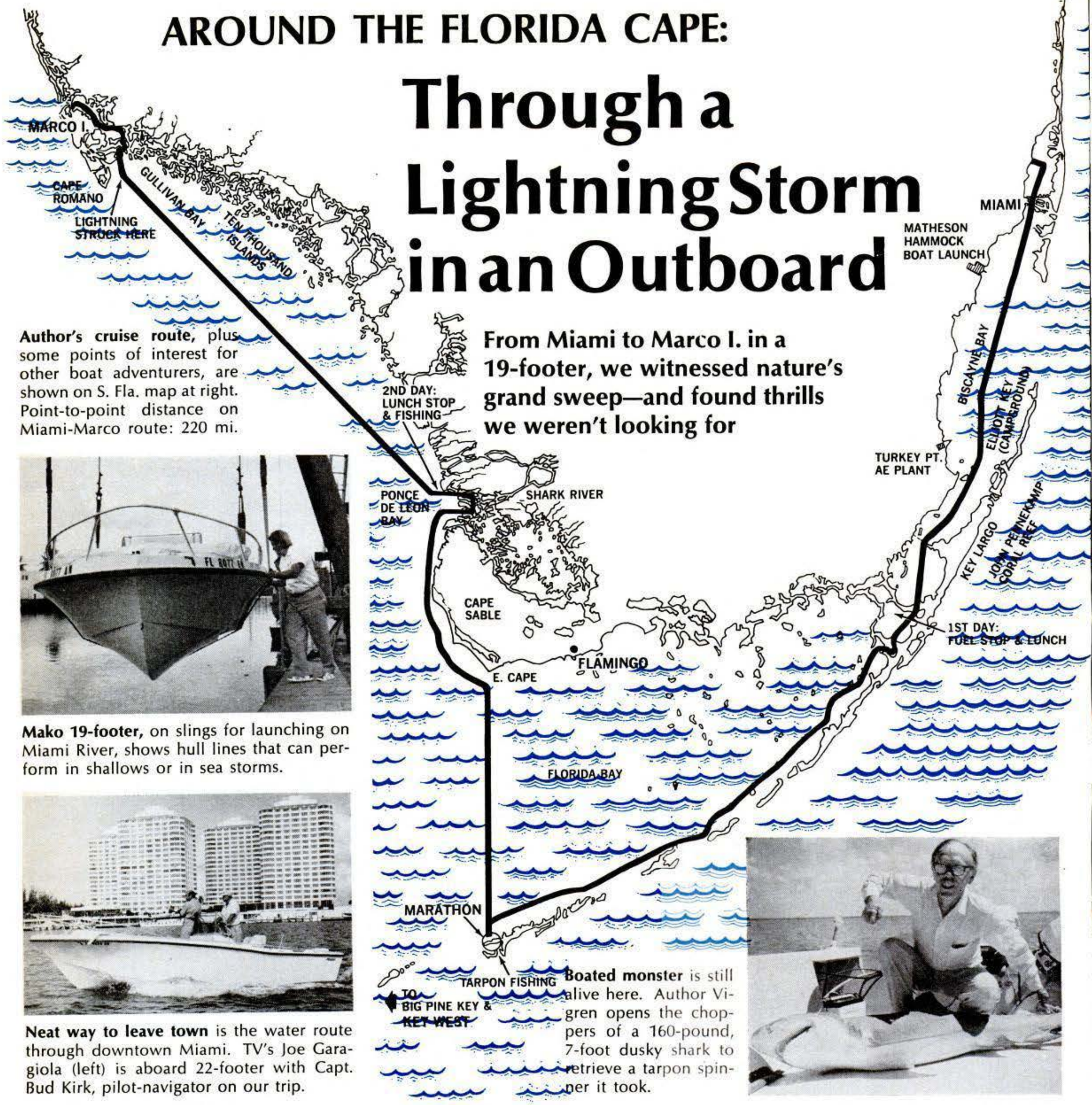
AROUND THE FLORIDA CAPE:

Through a Lightning Storm in an Outboard

From Miami to Marco I. in a 19-footer, we witnessed nature's grand sweep—and found thrills we weren't looking for



Author's cruise route, plus some points of interest for other boat adventurers, are shown on S. Fla. map at right. Point-to-point distance on Miami-Marco route: 220 mi.

Mako 19-footer, on slings for launching on Miami River, shows hull lines that can perform in shallows or in sea storms.

Neat way to leave town is the water route through downtown Miami. TV's Joe Garagiola (left) is aboard 22-footer with Capt. Bud Kirk, pilot-navigator on our trip.

Leaving Marathon with full tanks for crossing to Cape Sable and final leg to Marco, bigger boat (foreground) carries 60 gallons.

Boated monster is still alive here. Author Vigren opens the choppers of a 160-pound, 7-foot dusky shark to retrieve a tarpon spinner it took.

By DAVID D. VIGREN

We pulled ourselves out of our boats at the Marco Island marina, a moderated crew. Perhaps we'd left some of the self out in the storm, and in the grand sweep of South Florida nature we'd seen.

Outboarding 220 miles from Miami to Marco through the Keys in only two days, we had found time to hunt tarpon, study marine life, and prowl into the jungle mouth of the Everglade's Shark River.

And been caught for it—by a predictable storm of unpredictably severe force, just short of our destination. Our pilot-navigator was nearly killed by lightning. I still feel awed by our adventure, though I'd do it again.

Good equipment and comrades. Boats and motors were all we needed for this trip, but completely reliable types. At seven a.m. on August 15 we put two open Mako boats of 19 and 22 feet into the Miami River. On each was a single Johnson 125.

Cruise leader was Capt. Bud Kirk, distinguished South Florida guide and naturalist, who led the way in the bigger boat. With him was Joe Garagiola, TV personality and former baseball big-leaguer, and Bob Stearns, a

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marine scientist at the University of Miami. Jesse Nicotera, from Johnson Motors, shared the 19-footer with me.

Running at low speed, we cleared the river bridges and ocean causeways south into Biscayne Bay in under a half-hour. Smog, then smoke, persisted until we reached Turkey Creek. We stopped just off the South Florida Power Co.'s nuclear generating plant to examine marine life in the shallows. Under Bob Stearn's tutelage we found live sponge and coral, anemone, baby fishes and crustacea in the turtle grass, which is one of the most essential producers in the Bay. A great variety of juvenile forms develop there, then move out.

It's hard to get lost. We followed the well-marked Inland Waterways down the Keys, making speed in open waters, slowing to cut closely through mangrove passes. Both Makos were proving to be good trippers, reasonably comfortable, and easy to handle in a variety of conditions with the big Johnsons.

Your skin, the water, the air you breathe—it all feels clean in the Keys. We laughed a lot, and Joe G. told a stream of stories, like the time he was catching at Wrigley Field and told the batter what he signaled for every pitch—who didn't believe him, and struck out, cussing.

We reached Marathon (halfway point) at four p.m.; picked up Bill Prentiss of Marco Island, who had arranged to meet us there; then out again in force with tarpon-hunter Calvin Cochron. Now, tarpon—a wild-jumping, fighting fish that reaches great size—are hard to find on a moment's notice. Cal did it. He suddenly hissed, shot a Grizzly hair fly on his floating line, and had a 60-pounder on. Joe G. played a big tarpon for half an hour before the battle ended in a deadlock.

Look out when you take side jaunts out of the main channels. Circling some tiny islands to reach the ocean pass where we fished, the 22-footer made a fast wrong turn (Bud wasn't at the helm) and grounded solidly on the shallow flats. Bill Prentiss got out and pushed while others put their weight on the bow to raise the propeller, and that motor egg-beat its way out of there. No prop damage.

Marathon to Cape Sable. Next morning there was not a cloud in the half-globe of our sky. Weather forecast was sunny, with local thunderstorms. It's only 30 miles across Florida Bay; yet, out of sight of land in a small boat you take the sea seriously, get tough as the wind and waves try to steer the boat.

Experienced Keys boatmen suggest making the crossing together with an-

[Continued on page 150]

Left turn at E. Cape let boats dodge the first thunderhead, which blew toward Flamingo. They steered on tall, isolated palm tree coming in, then followed the beach.

Set for the blow, Prentiss and Nicotera tie down the canvas—Vigren's at the helm. With 125 horsepower the boat handled well and held headway even at peak of storm.

Thankful crews collect themselves, safe in Marco marina. Canvas for helm station was not up on the 22-footer, left. Bud Kirk was exposed when the lightning hit him.

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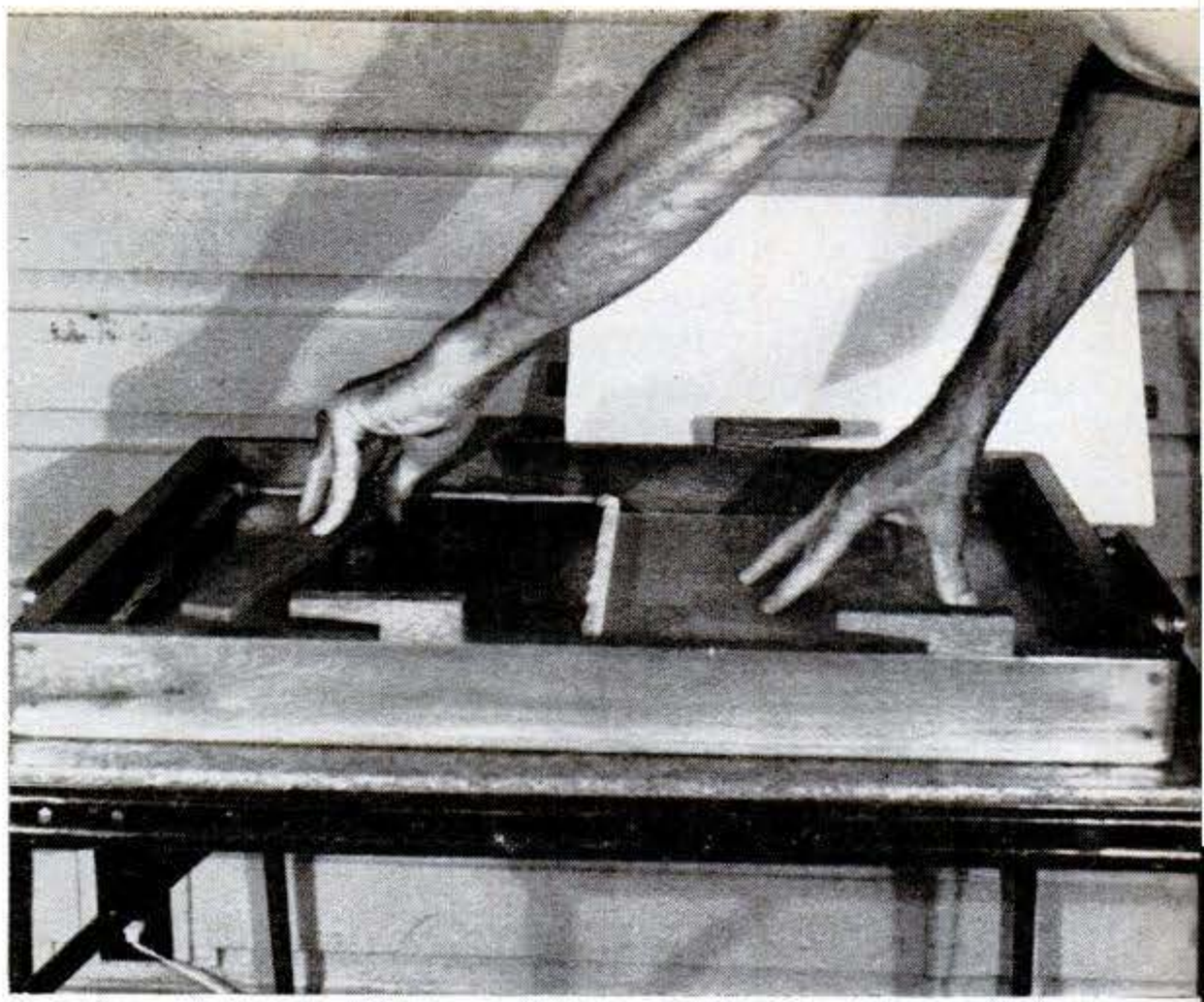
BLUEPRINTING ...Your Best Bet in Home Shop Copying

The classic method of reproducing drawings is still without peer when it comes to clarity, simplicity, economy—and size

By E. CARLYLE LYNCH



Blueprinting sun frame you build from the plans at right makes prints up to 18" by 24". Its twin pressure arms assure good contact between original sketch and blueprint paper.

Blueprinting is on its way to becoming a lost art—and that's too bad. It can't be topped for making excellent and inexpensive reproductions of plans and drawings. We all commonly use the word blueprint, but many younger people never have seen a real blueprint—clear white lines on a blue background. Any drawing made on translucent paper with opaque ink, soft pencil, charcoal, or lithographic or china-marking pencil can be copied this way.

A blueprint results when opaqueness blocks out light from a light-sensitive, pale greenish-blue coating on white paper. Where the light can penetrate to the paper, the blue coating is set, and darkens slightly. Where light can't reach the paper, the coating washes off when the paper is immersed in water after exposure. At this point a faint image is visible.

A second bath—in a solution of potassium bichromate—intensifies the image by darkening the blue background. Thus we get white lines on a blue ground. The paper is inexpensive. Sold by the yard, it comes in widths 30 inches or wider.

Blueprinting used to be the only way to make prints. (The Ozalid process—using ammonia fumes—has now almost replaced it.) But you can do your own blueprinting by making the equipment at right, and by using the sun as a light source for exposure.

To make a blueprint. Put your tracing-paper drawing face down on a sheet of glass, back it with the light-sensitive paper, cover with something to keep drawing and paper in close contact, and turn the glass face to the sun for an exposure that depends on the speed of the paper—ordinarily 30 to 45 seconds on a sunny day, but sometimes as long as 25 minutes on a cloudy winter day.

Now immerse the exposed paper in clear water long enough to wet it all over. Stroking the surface speeds wetting. Next, withdraw the wet paper and immerse it in another container of water made slightly orange-colored by dissolving potassium bichromate in it. This enriches and sets the color and prevents fading. After a few minutes in the bichromate bath, rinse off the print in the first bath, and hang it up with clothespins on an inside line to dry.

An architect or draftsman can help you locate an art-supply store that sells tracing and blueprint paper. Get potassium bi- or dichromate at the art store or a drugstore. It's $2 a pound (a pound lasts a long time). A large mailing tube with one closed end and a fatter short length (also with closed end) to fit over it provides light-tight paper storage.

The sun frame. It will make prints up to 18" by 24". Double-strength glass adds weight but is safer. Two small pressure plates instead of one large one make the frame easier to load and put a more even pressure on the paper. A good trick for loading: have thin cardboard or Bristol board handy to lay over the print paper before the pressure plates are put on. Cut it ½" smaller each way than the frame opening and glue on a tape handle for easy lifting.

Trays for washing small prints can be glass or aluminum baking dishes or cake pans. For larger work, make the wooden frame and two aluminum trays shown at right. Soft sheet such as Reynolds' Do-It-Yourself aluminum is fine for the trays.

Making prints. You can cut the paper for your prints (in a room with one dim lamp) the night before you expose them. Since the paper is white on the back, roll it out on a bed (good for holding the roll from rerolling), sensitive side down, and pencil-mark for cutting. Store the cut sheets in a light-tight tube until loading time. Load your frame in subdued light (indoors) and then step out into the bright sun. Take only one sheet of paper out of your paper safe at a time. Even subdued light can fog one sheet while you're working with another.

Before making the exposures, put about ½" of water (this will be a gallon in the trays shown) in each of your washing trays. Leave the first one clear but add ¼ teaspoon of powdered potassium bichromate to a gallon of water in the other tray. Stir around to dissolve.

If your bichromate is in crystal or granule form, put some in an envelope and powder it with a hammer. The water must contain enough to turn it slightly orange-colored. (CAUTION: Potassium bichromate is poison. Keep it out of the reach of children.) A gallon of water in each tray is sufficient for washing a dozen 18"-by-24" prints before the water will "wear out."

Use a large sponge to take up the water for squeezing into a bucket. This is simpler than putting drains in the trays. The sponge can be used at the same time to wipe out and clean the trays. Newspaper under the clothesline where you dry your prints may help domestic relations. PS

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MATERIALS FOR BLUE-PRINT FRAME

- 2 PC 3/4" x 2 1/4" x 25 3/4" PINE SIDES
- 2 PC 3/4" x 2 1/4" x 20 1/4" PINE ENDS
- 2 PC 5/16" x 3/4" x 26 1/4" GLASS RETAINER STRIPS
- 2 PC 5/16" x 3/4" x 20 1/4" GLASS RETAINER STRIPS
- 4 PC 3/4" x 1" x 4" OAK LOCK CLEATS
- 2 PC 5/16" x 1 1/4" x 20 1/2" OAK LOCK SPRING
- 2 PC 1 1/8" x 2" x 16" OAK BATTENS
- 2 PC 5/16" x 1 1/8" x 8" OAK HANDLE
- 2 PC 3/8" x 12 5/16" x 18 5/8" PLYWOOD PRESSURE PLATES
- 4 SPOOLS 1" DIA. x 1 1/4" HANDLE SPACERS
- 1 PANE 19 1/4" x 25 1/4" GLASS
- 2 YD. WHITE COTTON FLANNEL 36" WIDE TO PAD PRESSURE PLATES. TACK DOWN WITH N° 2 UPHOLSTERY TACKS
- 1 PC BRISTOL BOARD OR SINGLE-WEIGHT MOUNTING BOARD 18" x 24"

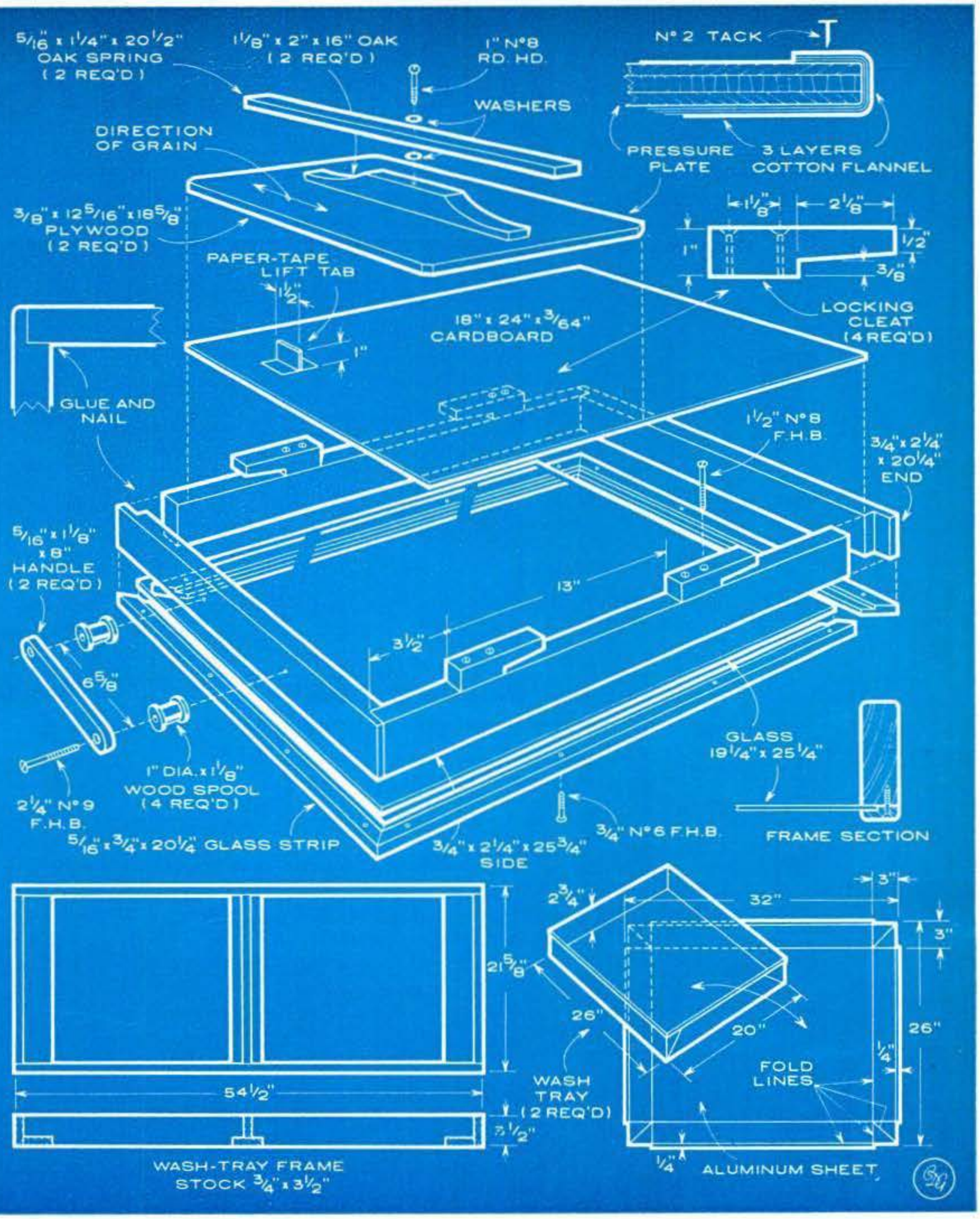
WOOD SCREWS

- 16, 3/4" N° 6 F.H. BRIGHT
- 2, 1" N° 8 R.H. BLUED AND TWO 3/16" WASHERS, FLAT
- 8, 1 1/2" N° 8 F.H.
- 4, 2 1/4" N° 9 F.H.
- 1 PC GUMMED PAPER TAPE 1 1/2" x 4" (LIFT TAB)

MATERIALS FOR WASH TRAYS

- 2 PC 3/4" x 3 1/2" x 54 1/2" PINE SIDES
- 5 PC 3/4" x 3 1/2" x 20 1/8" PINE ENDS AND BOTTOM SUPPORTS
- 1 PC 3/4" x 2 3/4" x 20 1/8" PINE PARTITION
- 2 PC 26" x 32" ALUMINUM SHEET

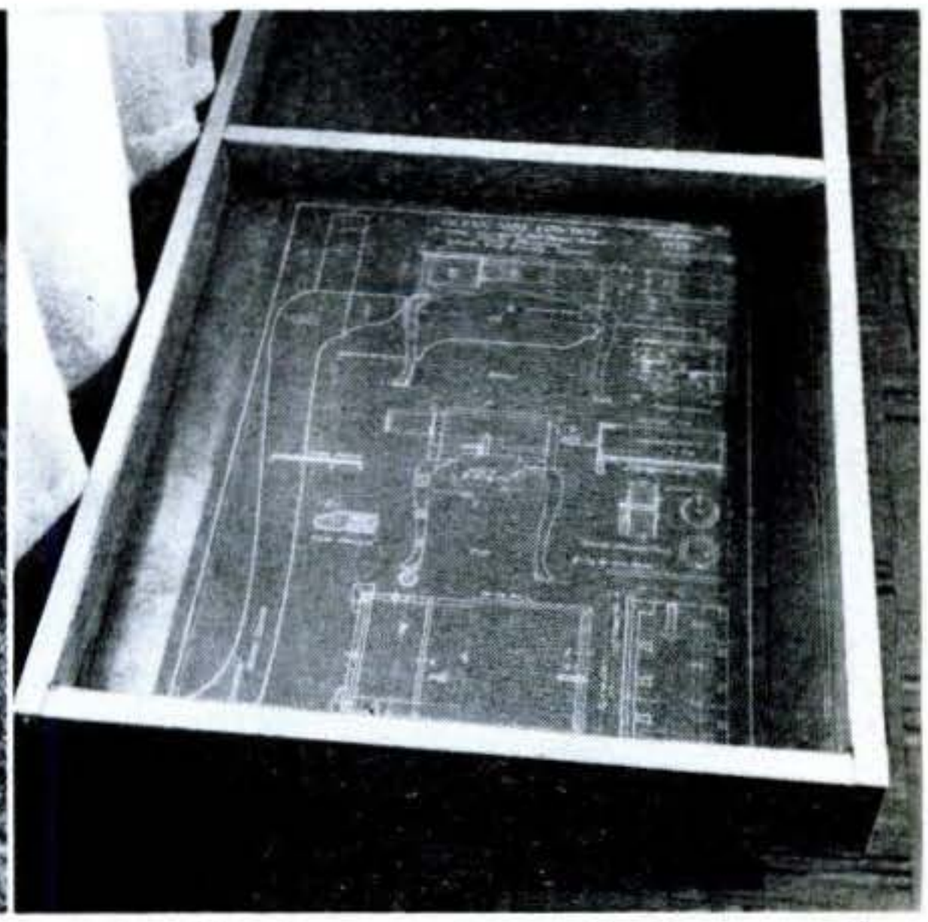
ASSEMBLE FRAME WITH 6 D AND 8 D BOX OR FINISHING NAILS



Clear white lines on a blue background—blueprints give you beauty and clarity unmatched by more modern means of reproduction.

A stovepipe paper safe is easy to make. Cap one end, make a slide-on top for the other. Black plastic bag is even simpler.

Exposures in bright sunlight average around 30 seconds. Underexposure gives very light prints; overexposures will be too dark.



Aluminum trays in wooden frame provide a convenient set-up for water and bichromate baths. For details, see blueprint above.

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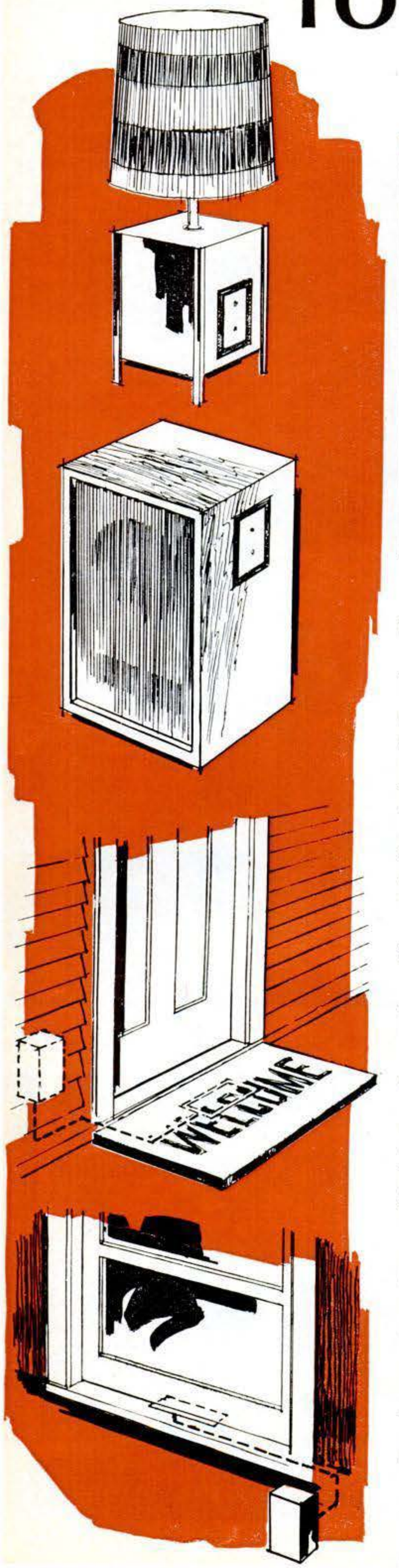
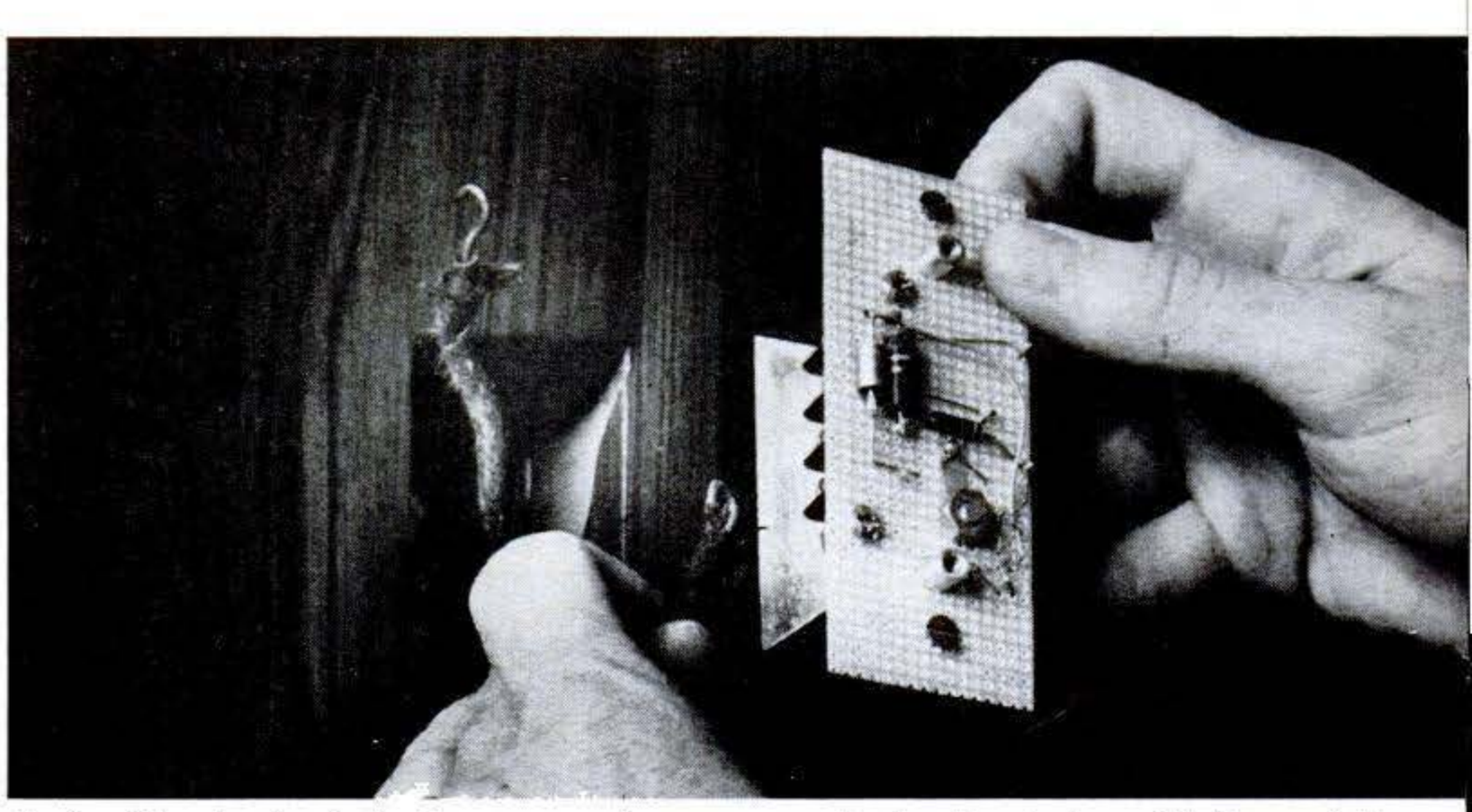
TOUCH MODULE—This

Touch it once, it closes the circuit. Touch it again and





No fumbling in the dark when you replace your standard wall switches with the module.

By STU HOBERMAN

What's so great about a proximity switch? Plenty. The basic idea, of course, isn't new, but a simple circuit that does practical work is. Touch the plate once and the circuit is closed; touch again, it opens.

- Use it as a wall light switch. It makes a unique entry convenience for any room—with a bonus: not having to fumble for the switch in the dark.
- Add the same convenience to any standard lamp. No chains to pull or buttons to find—just touch the side.
- Remote speakers around your home? Add a module to the side of the enclosure; they go off at a touch. It's perfect for when the phone rings or if you just want some quiet.
- Remove the front plate and run a wire to a larger plate—under the door mat, for example. The increased plate size automatically increases the sensitivity and would ring the doorbell when a visitor arrives.
- Using this same idea, run a wire around the frame of your windows. The module can then do much more than ring a doorbell when a visitor arrives from this direction.

The Touch Module will solve many previous switching problems and help create new applications limited only by your imagination. Got an unlit staircase? Run a fine wire under the bannister. Placing your hand under the bannister anywhere along the line turns the lights on or off.

How it works. Proximity switches detect an added capacitance in the circuit. In this case, the additional capacitance—your body—allows an AC voltage to flow into transistor Q. Once amplified by Q, it is regulated by the zener diode and used to trigger the SCR. The voltage from the SCR is then filtered by the electrolytic capacitor and triggers the latching relay.

The latching relay mechanically creates the touch-on/touch-off effect. If, instead, you want the module to close the circuit when touched and allow it to open as soon as you remove your hand, then substitute a standard relay for the latching one. A Cornell Dubilier 603-24 is the standard relay replacement for the latching relay used here.

Construction. Component layout, hole spacing, and board size are designed so the module will physically replace a standard light switch. If, however, you wish to use it in a burglar alarm system, for example, cut the ends of the board off and mount the assembly in a small box.

Wiring is not critical, but be sure no wires touch the ¼" metal spacers or aluminum protective shroud. If a cover plate is used, periodically check that it does not short to any components once it is screwed in place. You may have to use a second nut on the SCR to shim it up high enough to clear the plate.

A solder lug is used under the screw of one spacer to connect the circuit to the cover plate. If a cover is not used, run the connecting wire from under a screw in the spacer.

The cover plate can be made from

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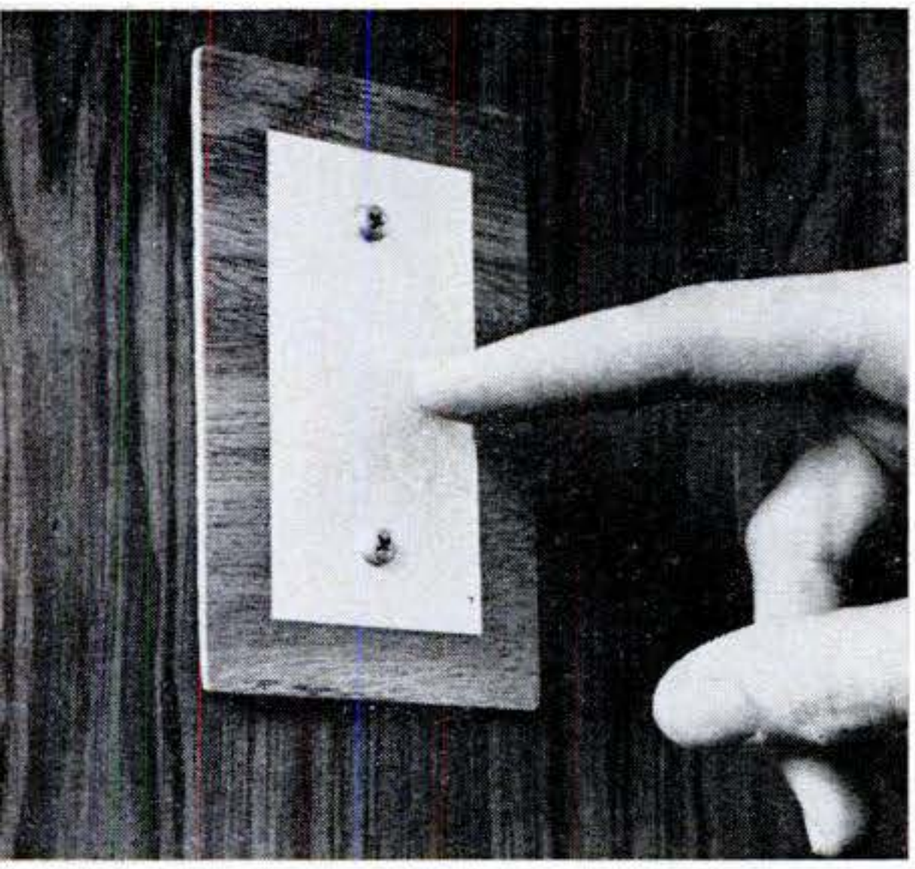
New Version Does Many Jobs

the circuit opens



Lights go on and off at slightest touch.

any scrap of aluminum. Cut it to dimensions of a standard switch plate and sand it down with coarse sandpaper to give it a finished surface. You can mount the plate as is or, if you prefer, finish the edges with Contact paper to make it decorative.

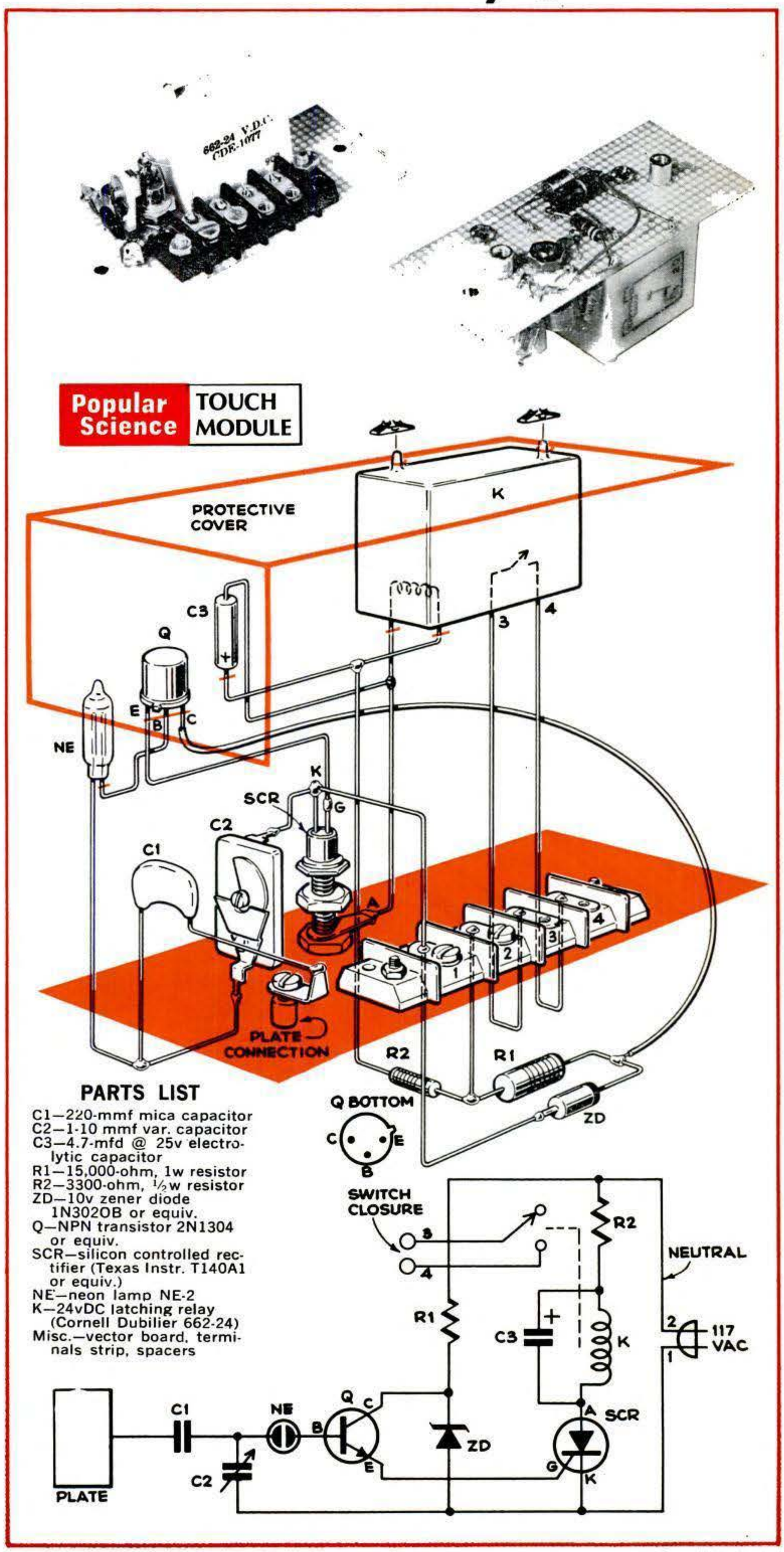
Final wiring. The four-lug terminal block has two connections for the 110-volt input and two connections for the relay contacts. Before mounting the switch, you may want to test it with a standard line cord connected to the input terminals. When plugged in, you should hear a definite click from the relay each time you touch the face plate. If not, turn the plug around. As shown in the drawing, the neutral side of the power line must be connected to lug 2 of the terminal block.

Relay contacts take the place of conventional switch contacts. Wire them to the circuit you are controlling, as you would a switch. Maximum rating of contacts is 300 watts.

Adjustment—if necessary. When using the Touch Module with an oversize plate or length of wire, the added capacitance automatically makes the module more sensitive. In some cases, it may become too sensitive, causing the relay to trip unexpectedly.

If this is the case, turn the trimmer capacitor C2 to lower the sensitivity. If the standard switch plate is used, the capacity is already low enough so the trimmer will have little effect.

When you've built one Touch Module and found how versatile it can be, you may find yourself ordering parts for another. PS



PARTS LIST

C1—220-mmf mica capacitor
C2—1-10 mmf var. capacitor
C3—4.7-mfd @ 25v electrolytic capacitor
R1—15,000-ohm, 1w resistor
R2—3300-ohm, ½w resistor
ZD—10v zener diode 1N3020B or equiv.
Q—NPN transistor 2N1304 or equiv.
SCR—silicon controlled rectifier (Texas Instr. T140A1 or equiv.)
NE—neon lamp NE-2
K—24vDC latching relay (Cornell Dubilier 662-24)
Misc.—vector board, terminals strip, spacers

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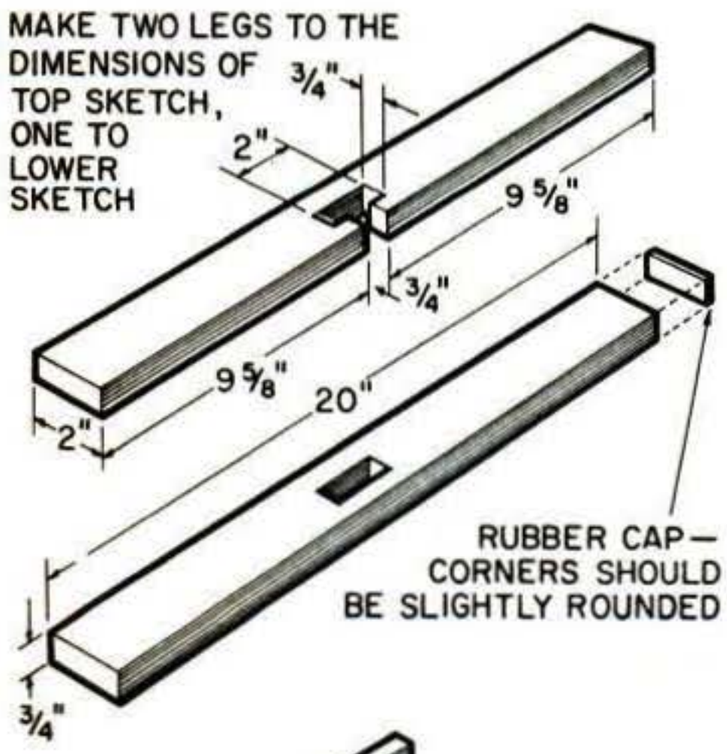
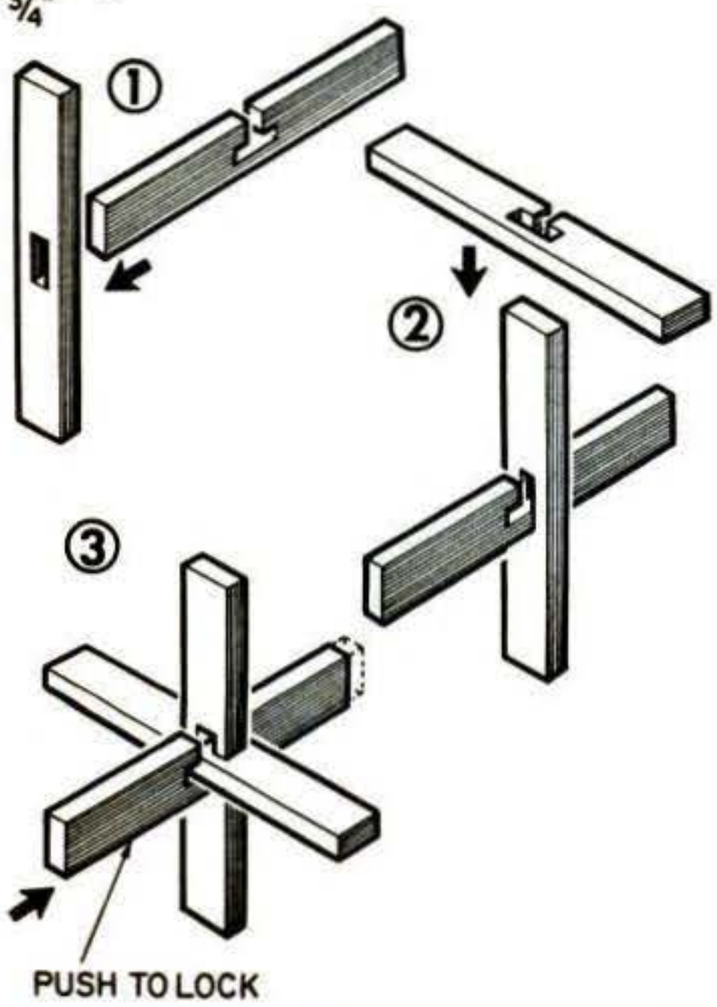
No fasteners of any kind join the four parts. The interlocking legs support a 21"-diameter smoked-glass top; both ends of each leg are padded with rubber.

PUZZLE TABLE

It's handsome (in oil-rubbed walnut), it's practical (comes apart for moving), but mainly it's fun: Lift off the ¼" plate-glass top and challenge your friends to take the base apart. It's a giant puzzle. Cut to dimensions shown, the legs form a table 12¾" tall. Pad ends with ⅛"-thick rubber soling from a shoe-repair shop to make them slip-proof.—*Randy Lorance*



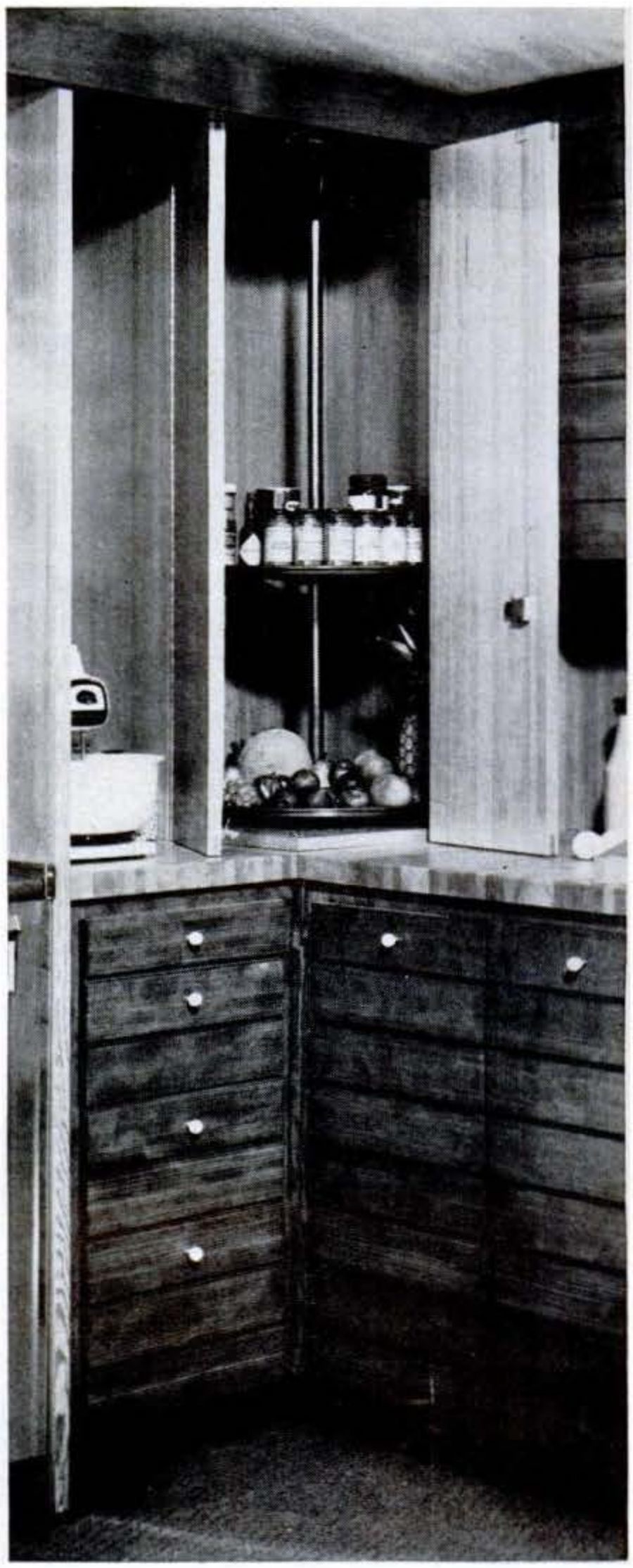


Action Cupboard for a Dead Kitchen Corner

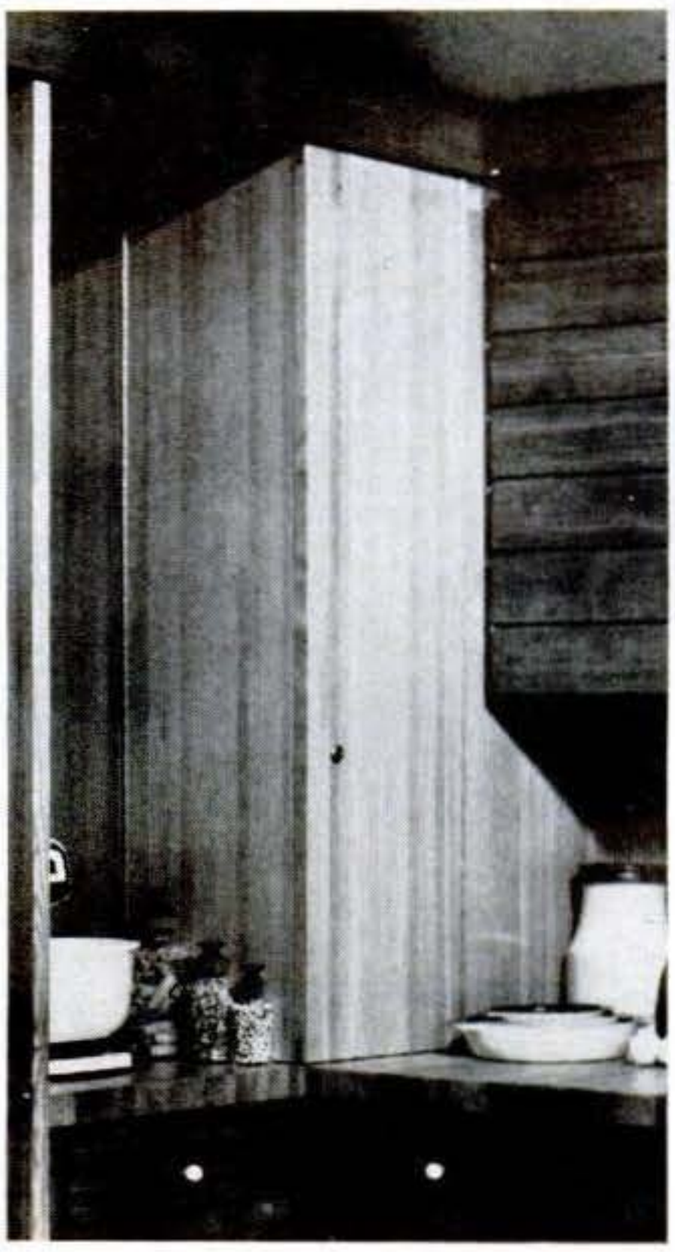
The boxed-in corner is double-hinged for easy access to several big lazy-susan shelves

Whenever kitchen cabinets turn a corner, they create a problem: no access to wasted corner space. Here's a simple but shrewd solution to the above-counter part of that problem. Box out the corner to take lazy-susan shelving—of a diameter that's just under counter-top width.

You can buy a ready-made metal shelf assembly (if you can find one to fit), or cut your own plywood disks to mount on pipe flanges. The doors need no jamb framing. Closure support is provided by a square base of ½" or ¾" stock plus a pair of magnetic catches mounted on the ceiling. The lock is optional—this cabinet was designed to hold liquor, as a feature of Western Wood Product's "Elbow Room."



Tall and skinny, the doors open against existing wall cabinets without crowding the counter-top space. The shelves inside spin to parade their full contents past the center access. Though only two are shown, unit could take up to four shelf disks.



Continuous hinges form a neat trim when doors are closed. The unit shown is built of laminated western pine, to tie in with the laminated "chopping-block" counter top, but solid stock—such as wide pine shelving—would do the job just as well.

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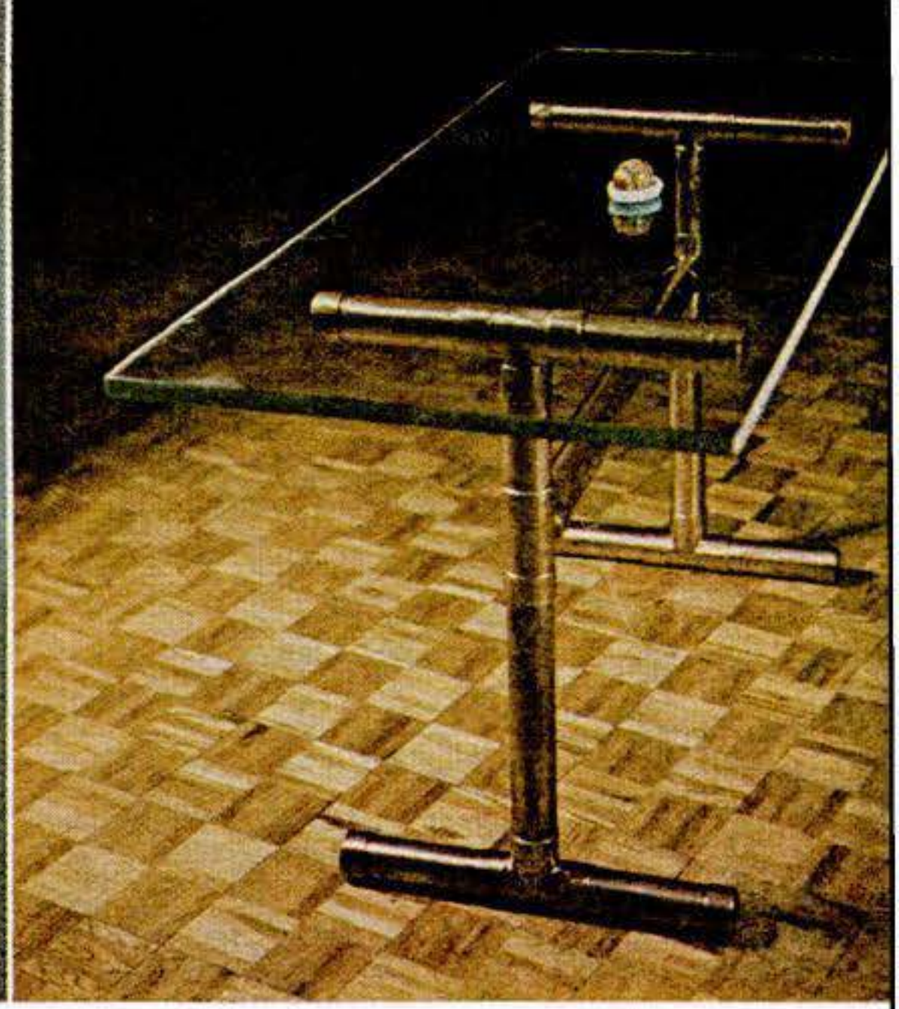


A Pair of Pipe Tables ...Take Your Pick

Take a glass or plywood top. Add ordinary water pipe. What do you have? An "instant coffee table"

By JOHN E. PITT and A. J. HAND

What's your bag in modern design? The now almost classical look of glass and metal? Or the sock-it-to-me world of bold and glossy color? Either way, we've got a coffee table to suit your tastes.

Despite their differences in visual impact, both tables are remarkably similar. Both are made from ordinary water pipe—one's copper, the other plastic. Both are ludicrously easy to build—so easy you can make your favorite with the simplest tools. Take the copper version: Have your plumbing dealer cut the pipe when you buy it; you can do the rest with a propane torch. The plastic table? An ordinary handsaw gets you through most of the work.

Costs? Here's where the tables part ways. The plastic table with a plywood top should cost you somewhere around $20. Copper and glass? This can vary widely, according to where you live. Even if you shop around, the glass will run $40 or so for a 2'-by-4' sheet ½" thick, depending on how you order the edges finished. And figure at least another $20 for the pipe and fittings in this model.

Making the copper table

Ordinary 2" copper water pipe is the basis for this design. Since it's usually sold only in 10-foot sections, the table is sized so you can make it from just that amount. The top is a 2'-by-4' sheet of ½" plate glass.

When you buy the pipe, ask the supplier to cut it into the necessary pieces with his pipe cutter. You'll need:

- Eight pieces 7" long (sidearms).
- Two pieces 4½" long (upper legs).
- Two pieces 11" long (lower legs).
- One piece 33" long (crossbar).

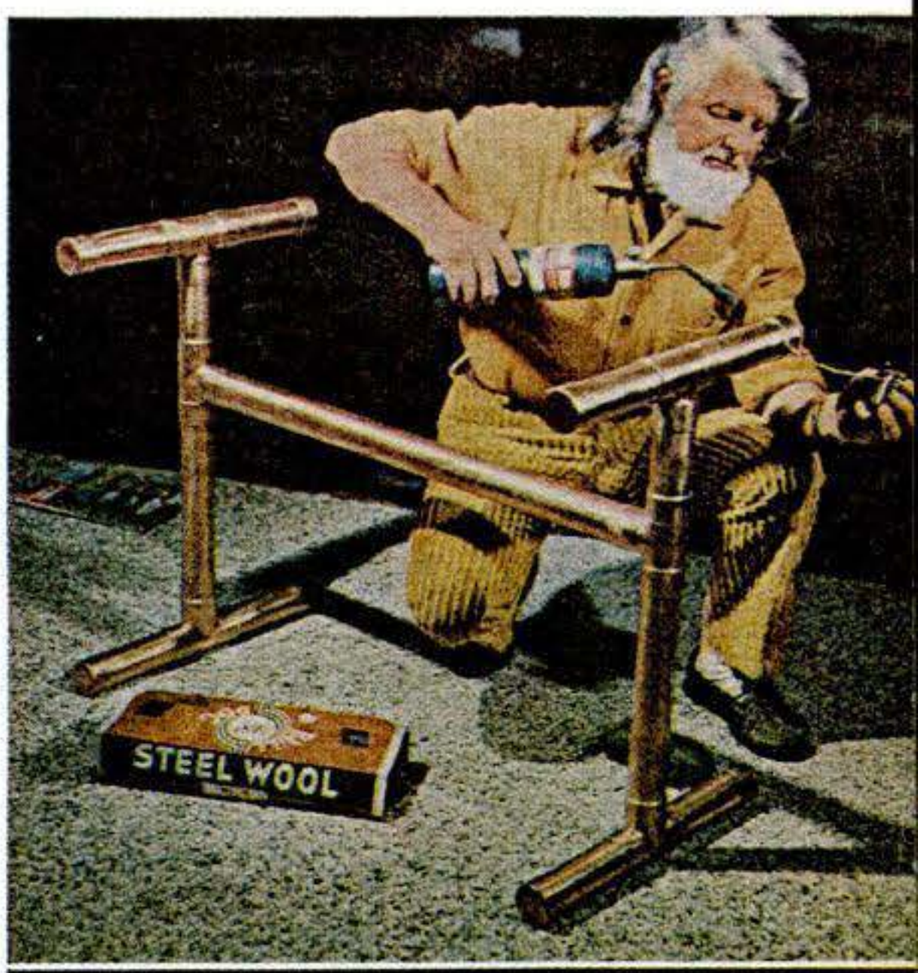
Ts and caps. Get these from your supplier, too. Make sure you get the smooth, wrought type of fitting—the cast variety is textured and a bad match for the pipe.

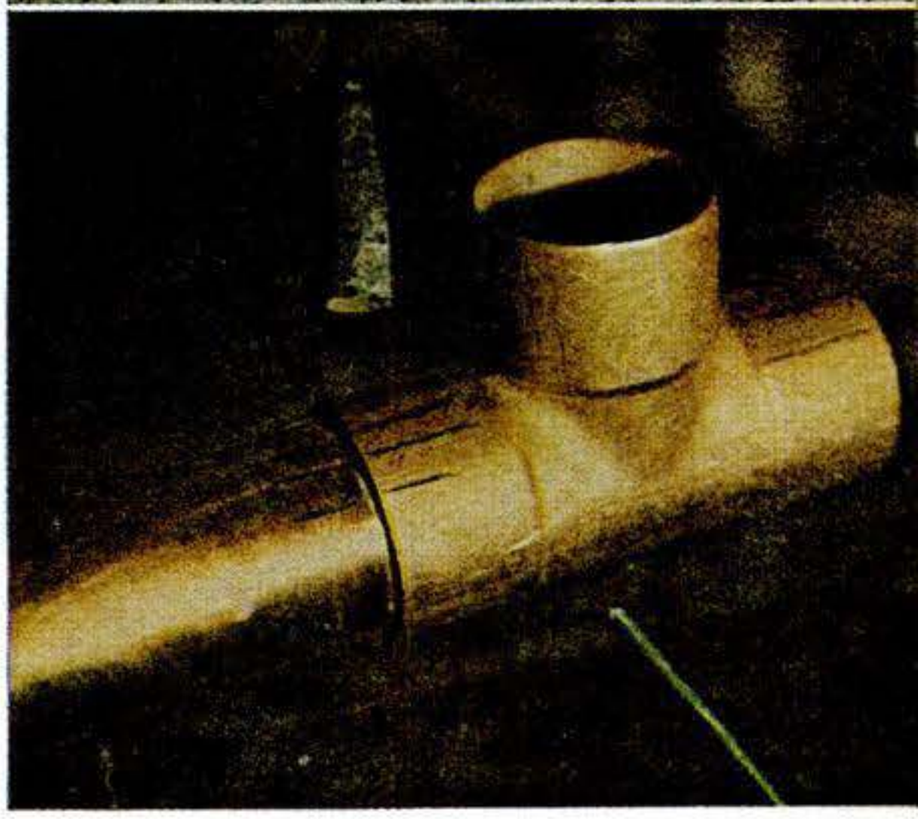
When you get the pipe and fittings home, temporarily assemble the pieces to check dimensions and fit. Then disconnect, and clean pipe ends and the insides of all fittings with steel wool. Wipe a small amount of flux inside each fitting and you're ready to solder.

Follow this sequence: It will make sure you get everything square. Caps go on first. Then add a T at each end of the crossbar. Lay this assembly flat on the floor while you work to assure alignment of the Ts. Next, add leg and side-arm sections to the four remaining Ts. Last, assemble the five components you've just built, checking with a square as you go.

In soldering, apply heat to the fitting—not the pipe—so you'll draw solder into the joint. Wipe off any excess solder with a rag before the joint cools.

Finishing up. Buff the pipe and fittings to a soft shine with steel wool. Follow up with a rag soaked in lacquer thinner (don't touch the metal with your bare hands) then spray on a light coat of clear lacquer. Cement leather or rubber pads to the top bearing points, and set the glass in place. Now bring on the coffee.—*John Pitt*





Please turn the page for instructions on building the plastic-and-plywood table

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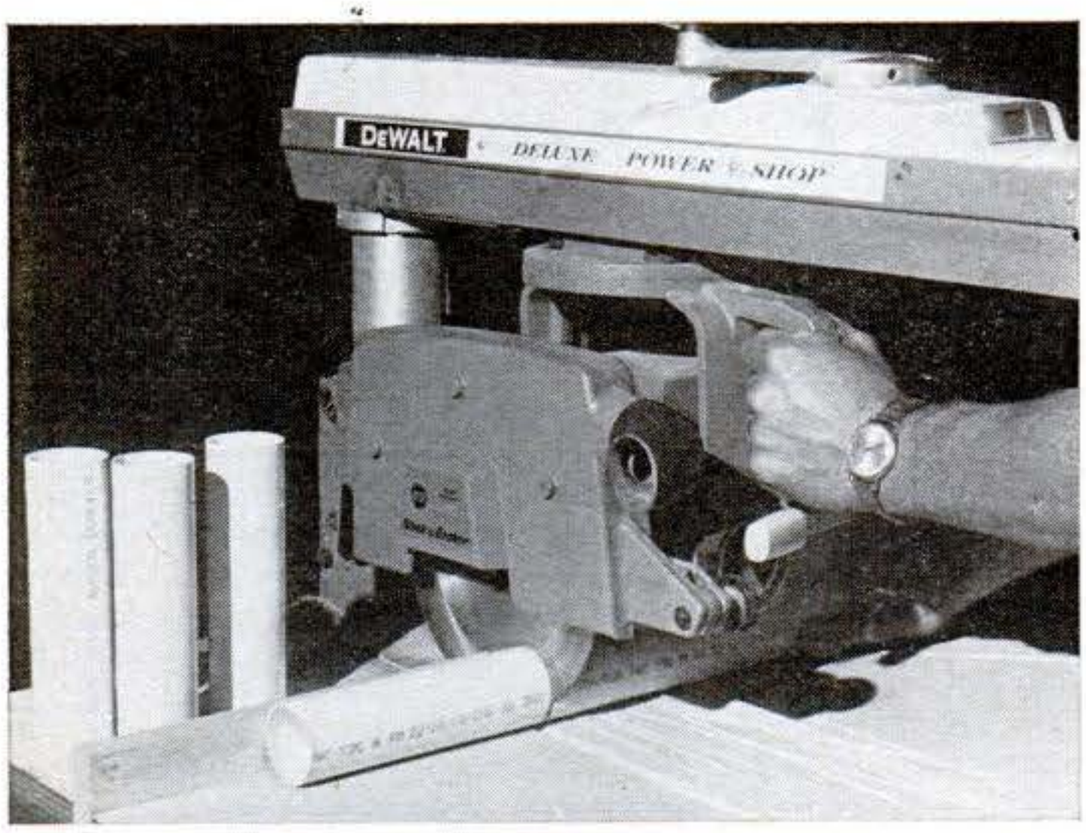
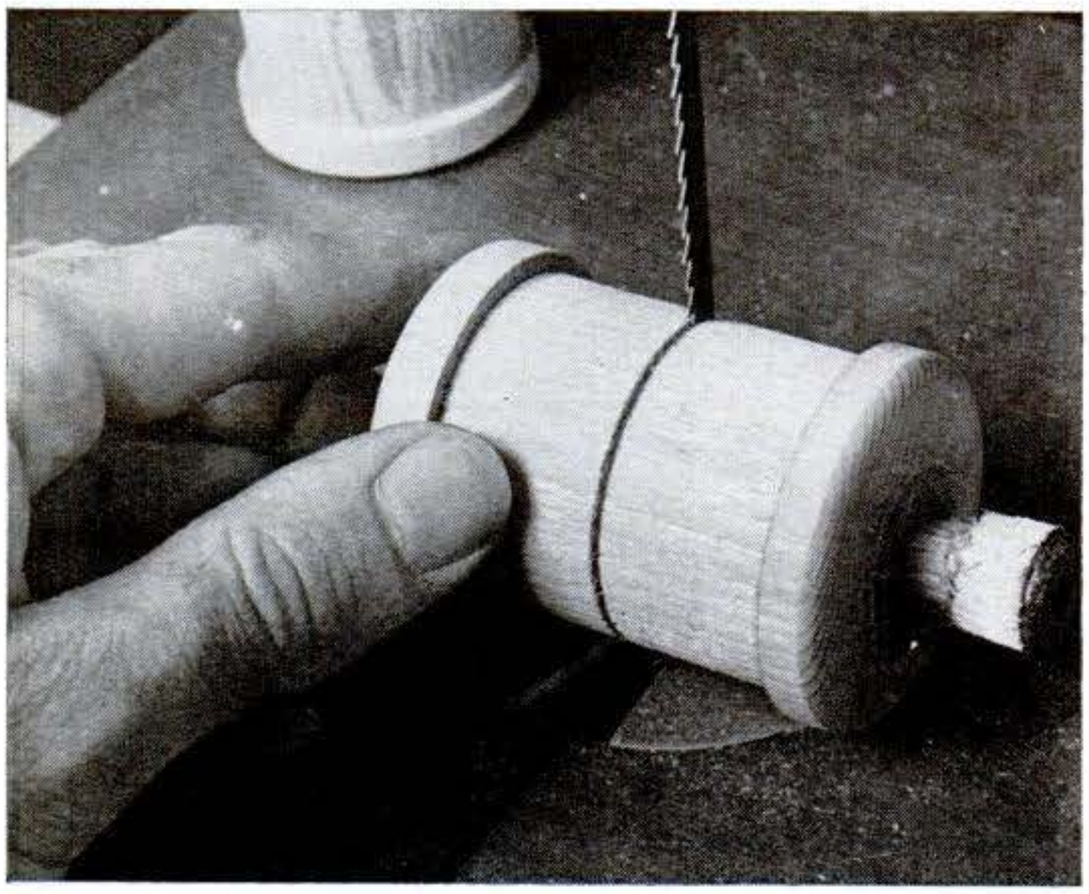
Building an "instant coffee table" with plastic pipe

Glass top goes well with the plastic pipe table if you don't go beyond the half-inch thickness. The plastic pipe isn't really sturdy enough to support heavier glass.



Radial-arm saw does a fine job on plastic pipe, but plastic cuts easily with a handsaw, too. Pipe shown here is Sear's 1½" cold-water pipe made in rigid PVC (polyvinyl chloride).



Optional glides for legs are turned in pairs, then cut in half. Cement them into the legs with the same adhesive used to join pipe and fittings. Paint along with pipe.

Like its copper counterpart on the preceding page, the plastic table is made from a standard 10-foot length of pipe, stock fittings, and a 2'-by-4' top. I got my pipe and fittings through the Sears catalog for a total of some 12 bucks. Most plumbing suppliers stock plastic pipe too; but make sure you get the right kind. PVC, CPVC, and ABS all work fine, as long as you get the *rigid* type. Stay away from polyethylene and polypropylene—they require special painting techniques.

When you buy your pipe and fittings, pick up a small can of joint cement. PVC, CPVC, and ABS all require different cements; get the right kind.

The pipe I used is Sears cold-water pipe in the 1½" size. Sears also stocks indoor drainage pipe in this size, but the Ts that go with it are unsatisfactory for building tables. They're "sanitary Ts" and their stems *curve* out of the crossbar rather than exiting at a right angle.

Cutting the pipe. Once you've got your pipe, cutting it for use is child's play. You need 12 pieces 7" long, one 33" long. I used a radial-arm saw with a fine-tooth blade, but an ordinary handsaw or hacksaw zips through the plastic with ease. Use a miter box to assure square cuts.

It's easiest to paint the parts before you assemble them. Lacquers and oil-base enamels are the way to go, and you'll get the best job if you spray. No sprayer? Turn to aerosols. Avoid water-base paints; they don't stick well to plastic in my experience.

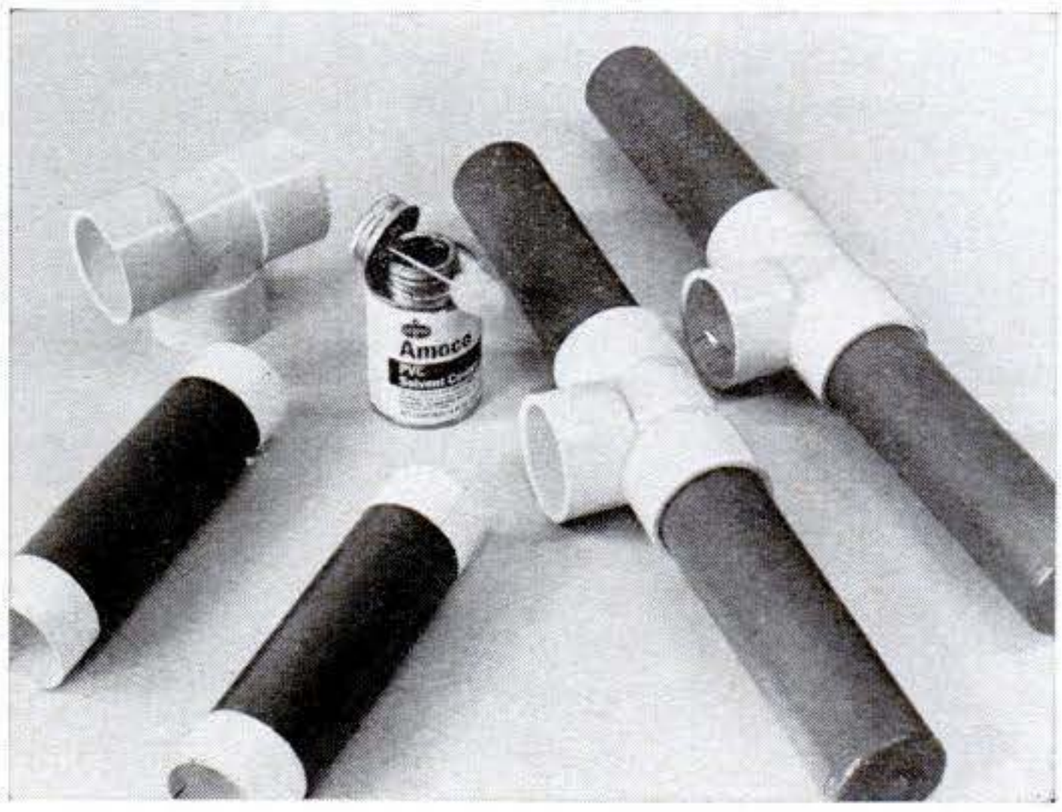
Before you paint, go over pipe fittings with fine sandpaper. Now is the time to file those obvious mold marks off the Ts. If you're using the wooden glides (in the photo at bottom left), cement these in place. Then wrap 1½" masking tape around all pipe ends that will fit into Ts.

You're ready to spray. The color scheme is up to you. I painted the Ts yellow to contrast with the blue enamel on the pipe. You may prefer to use just a single color, or go the other way and introduce a third or fourth color.

Assembly is almost like playing with Tinker Toys. Swab a light coat of cement inside a fitting, slip the pipe into the T until it stops. Twist it to distribute the cement, and let set. Don't go overboard on the amount of cement you use. Unlike a plumbing system, the table needn't hold water. Excess cement will ooze out of the joint and mar your paint job.

Topping it all off. Plywood or glass—the choice is yours. If you use plywood, you'll probably want to finish it to match the pipe framework. I used the same blue enamel that coated the pipe to finish the top surface of the plywood, then accented the edges with the yellow used on the Ts. Whatever you do, go over top and edges with a vinyl patching compound to fill any pits or chips before you paint. Then apply at least three coats of enamel, sanding between coats. This will give you the smooth, glossy finish you need for an effective pop look.

To fasten the top in place, turn or whittle four, 1"-long wooden plugs to fit snugly inside the legs. Screw and glue these to the bottom of the plywood, positioned so they'll drop into the legs when you set the top in place. Cement the plugs into the legs, or pin them if you want a removable top. To secure a glass top, cut four Plexiglas disks to fit inside the legs, and cement these to the glass with one of the new cyanoacrylate glues [see "Super-Strength Glue for Tough Jobs," PS, Sept. '72]. The weight of the glass will keep it down, the disks in the legs will keep it from skidding.—*A. J. Hand*



Solvent cement makes assembly of plastic pipe and Ts a snap. It comes in a can with applicator on the cap. Note wooden glides inserted in the legs at far right.

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The surprising Maverick: A new kind of luxury in compact cars.

It's our Luxury Decor Option, and here's what you get with it:

A vinyl grained roof. Vinyl-insert body moulding. Rubber-faced bumper guards. Radial-ply white sidewall tires. (Tests show that steel-belted radials can give average drivers 40,000 miles of tread wear under normal driving conditions.)

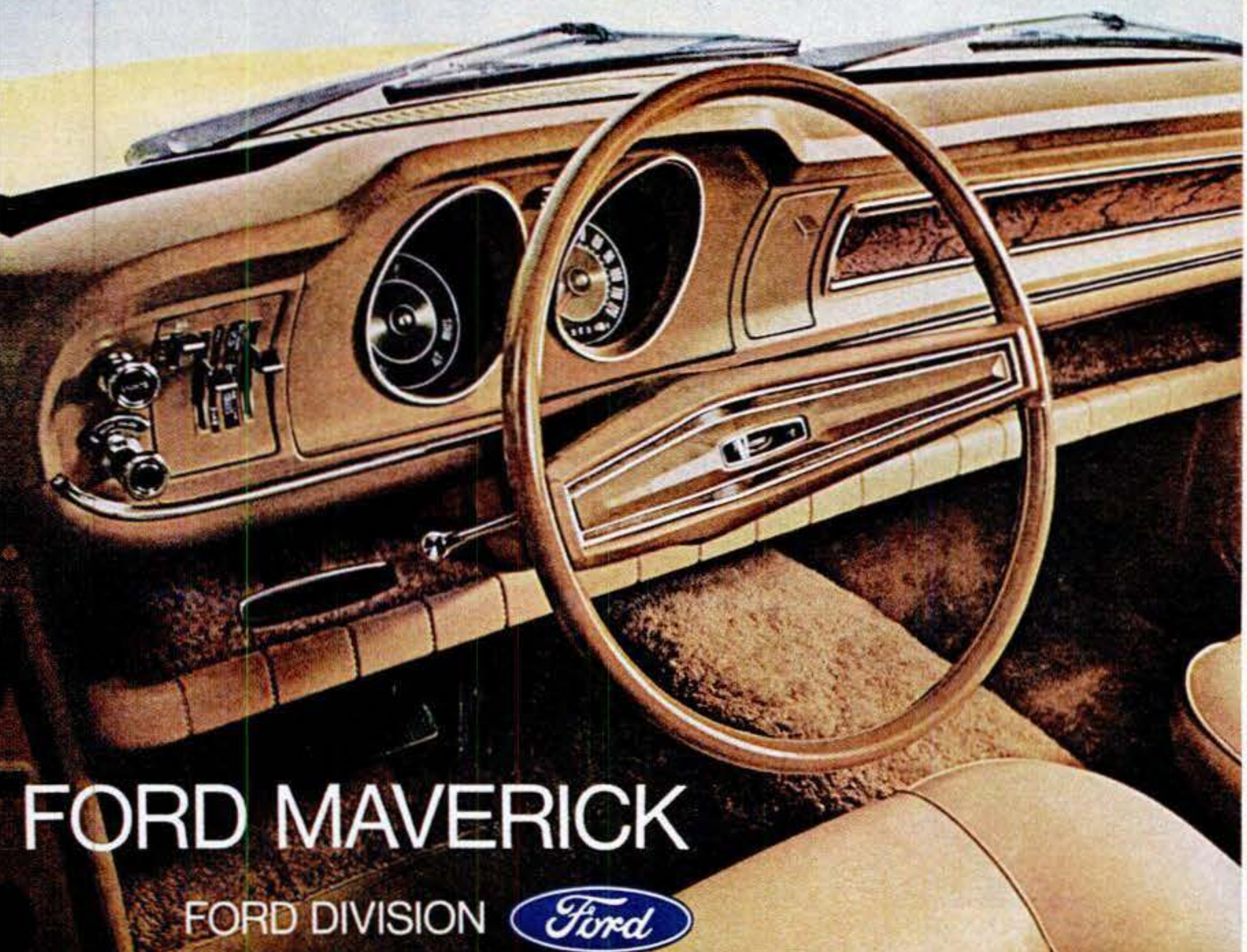
Glove-soft independent reclining seats. Cut pile carpeting throughout. Deep-padded doors. European type arm rests. Wood-grain dash. Insulation and suspension components designed for a remarkably smooth, quiet ride. And more.

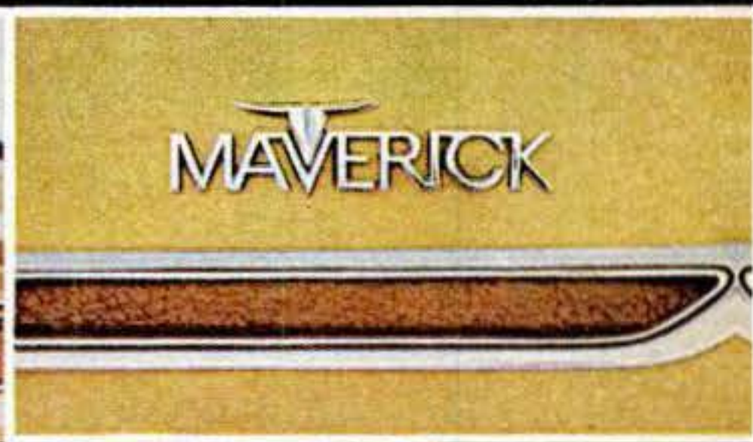
Sounds like a luxury car, doesn't it? It is.

See the Luxury Decor Option in the 2-door and 4-door Maverick at your Ford Dealer's.

Better idea for safety . . . buckle up!

Maverick is available now with optional 250-six automatic or 302-V8 engines.





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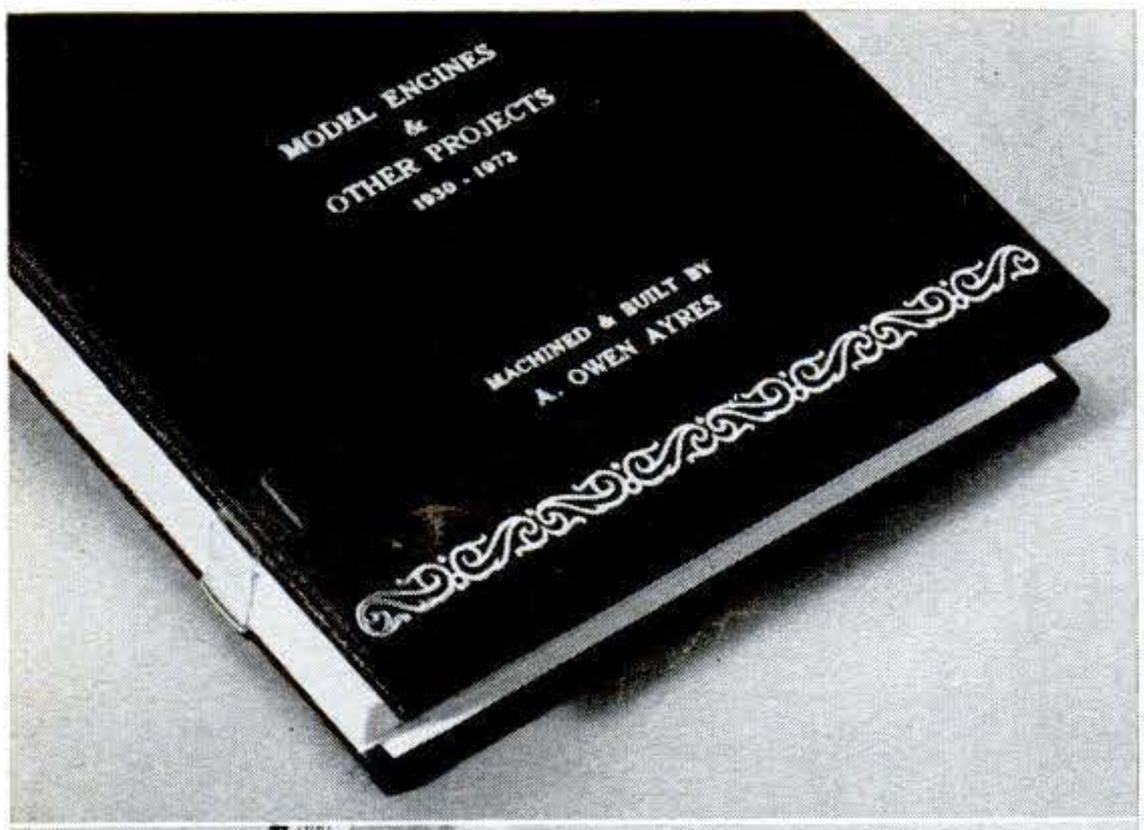
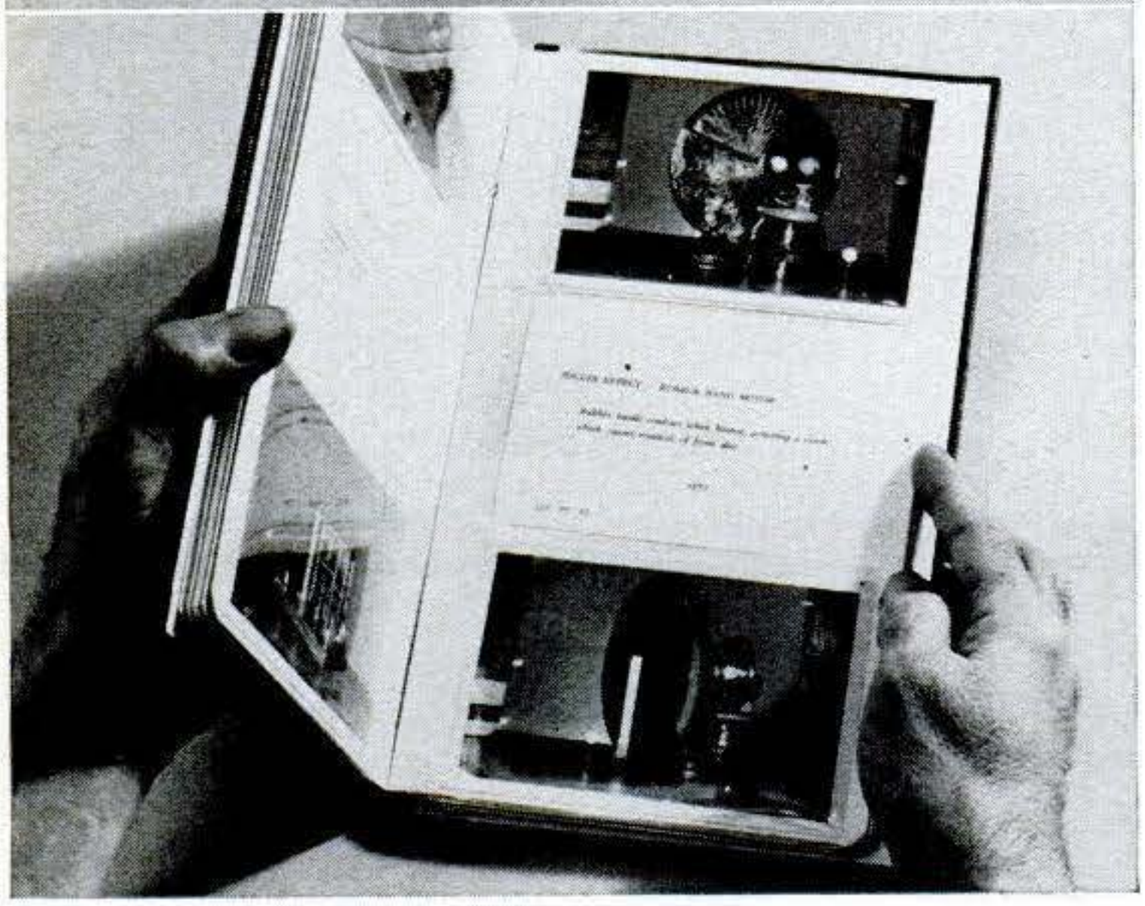
SHOP TALK

By AL LEES

For posterity: Keep a photo-album record of your workshop projects



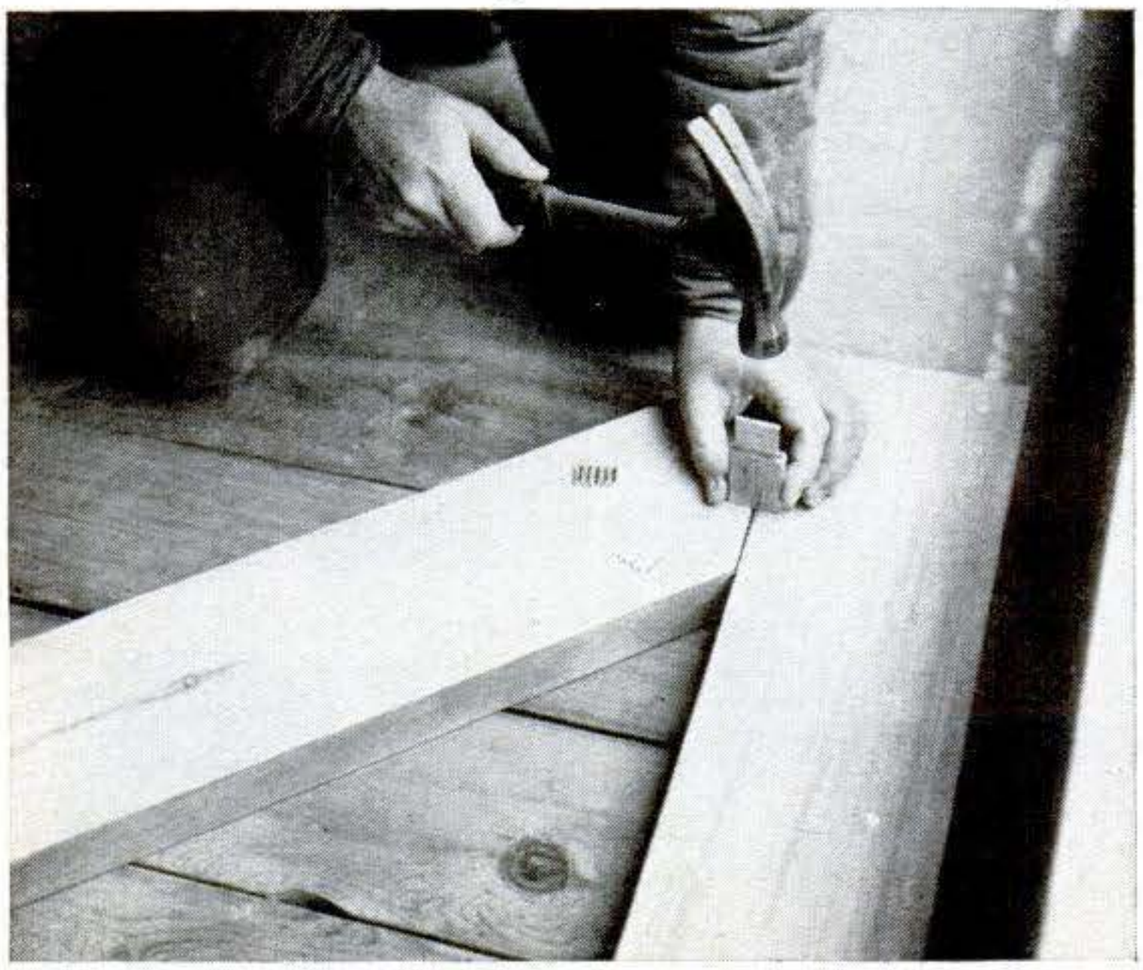


We've just added a unique book to our reference library—a gift from a reader we invite others to emulate. Owen Ayres of Eau Claire, Wis., sent a strap-bound, gold-printed portfolio of 40 years of shop projects. Top officer of a sand and gravel company, Ayres is also a confirmed modelmaker. He computes that he's invested one hour of his adult life in this hobby for every seven hours devoted to other work, and he rightly asserts that a record should be kept of so large an investment. Too often home craftsmen have little to show for their labors: Projects are scattered as gifts, lost, or destroyed. Even those that survive to become family heirlooms are so poorly documented no one can say when they were made or from what plans. The Ayres album records for all time vital facts on 18 engines he's built, many from our plans (in lower-left photo, album is open to his most recent: the Joule-effect "rubber-band motor" from Jan. '72). "Historical societies and museums," writes Ayres, "may value such albums someday." Meanwhile, *we* do.

Dept. of Further Research: where to write

Just had a chance to check out three booklets in the Commerce Dept's series of Urban Business Profiles. Practical advice on starting your own business in the field you're best qualified for, these 30¢ guides are available from the Supt. of Documents, Washington, D.C. 20402. Sample titles: "Machine Shop Job Work," "Building Service Contracting" (you'd offer cleaning and maintenance for office buildings), and "Photographic Studios" . . . Another government publication—this one in the Consumer Information Series published by General Services—is "Washers and Dryers," 22 magazine-size pages of advice on choosing and using home laundry equipment (45¢). Seven other booklets in the series cover such items as room air conditioners (45¢), vacuum cleaners and car batteries (40¢ ea.); when you order from Consumer Product Info., Washington, D.C. 20407, ask for a free index of 200 publications . . . Choose from five A-frame vacation-home plans in a $1 brochure from Alpine, Box 45012, Cleveland, Ohio 44145 . . . Edmund Scientific Co., 380 Edscorp Bldg., Barrington, N.J. 08007, has added 400 new products to its latest (free) catalog.

This month's light-bulb awards: a tiny tool and gassed glass for thermal windows



Stanley Works has been keeping us busy, of late, with a passel of new tools to try out. All simple, inexpensive, and hand-powered—but each born of a bright idea. We showed three of them in Nov. What's New, plus a centering square in a Sept. Personal-Use Report. I'm now playing with their latest—one of those silly-simple devices that leaves you incredulous that nobody's offered it before. It's a holder-set for corrugated nails—just an aluminum sleeve with a loose steel driver inside. At left, I'm using it to assemble cross-lap bracing of the deck shutters for the PS Lockbox leisure house. These 2-by-6 redwood units are a feature of the unique deck we'll tell you about in April.

Working through the winter, we welcome anything to speed the job, so Stanley's Sure-Drive lights our bulb. You line up the sleeve's center groove with your joint line, insert a fastener, drop in the driver and hammer it until a mark on it aligns with the top of the sleeve, telling you the nail's set flush. It's 99¢.

Another bright idea: Andersen, the window-maker, has improved its double glazing by replacing that 3/16" core of dead air with a dry gas that offers you 20-percent better insulation. For details write Andersen Corp., Bayport, Minn. PS

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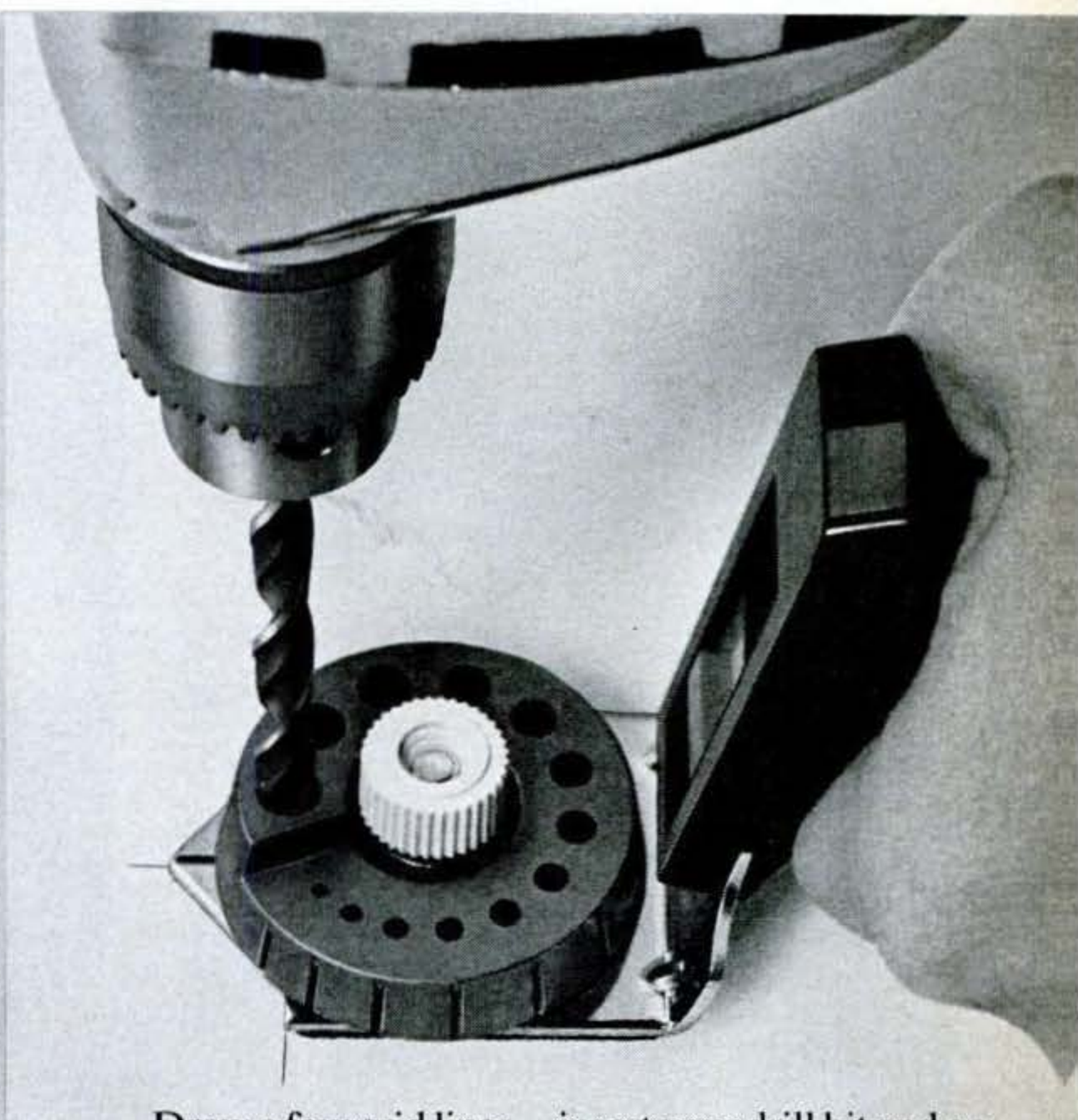
Stanley's Drill Guide has you going straight.

What can this new tool do for you? Guide your electric drill to a perfect right angle into metal, wood or plastic.

Just rotate the dial on the Drill Guide to the desired bit size. It accommodates 13 different bits, sized 1/16" to 1/4". Lock in place, drill away!

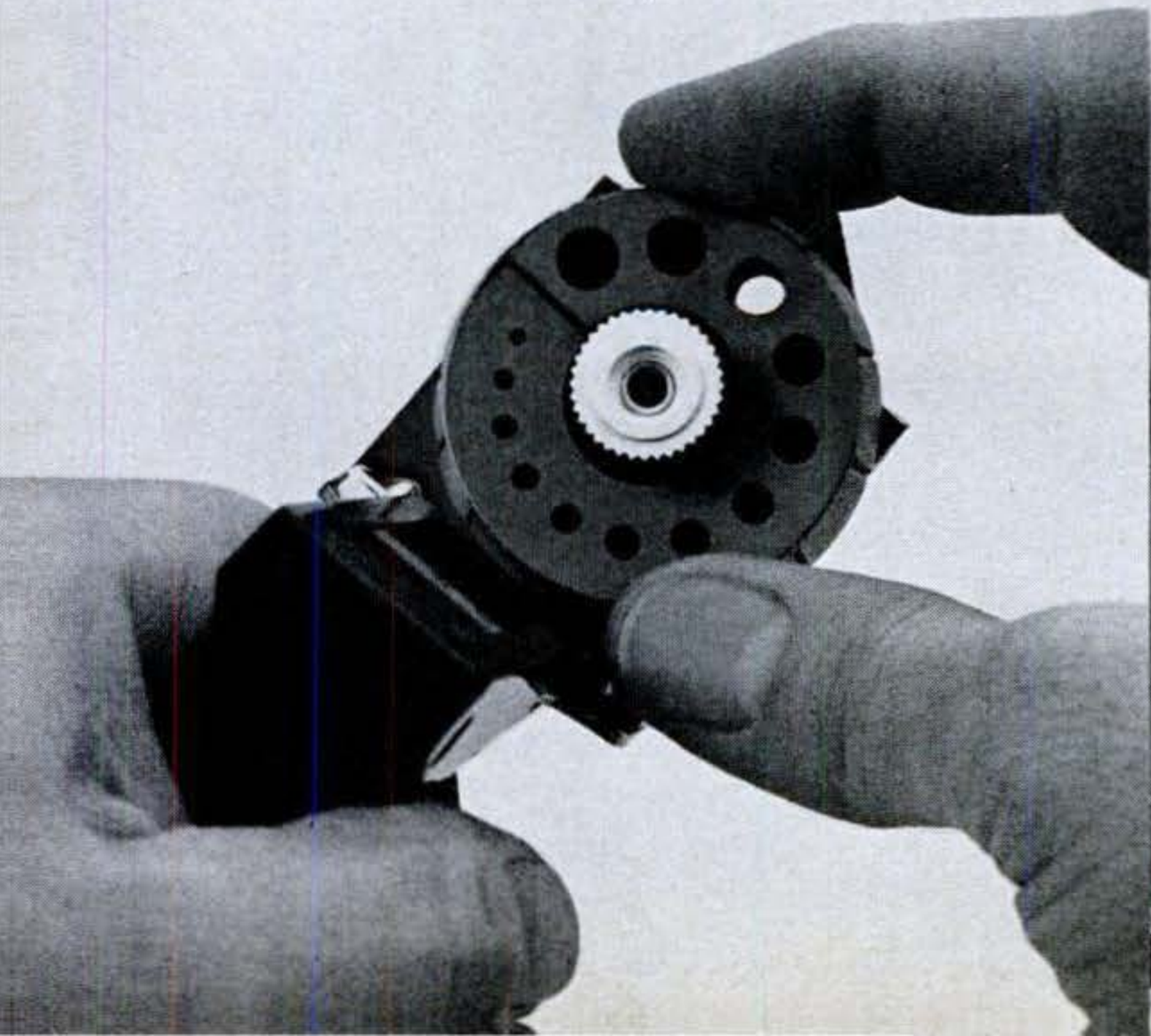


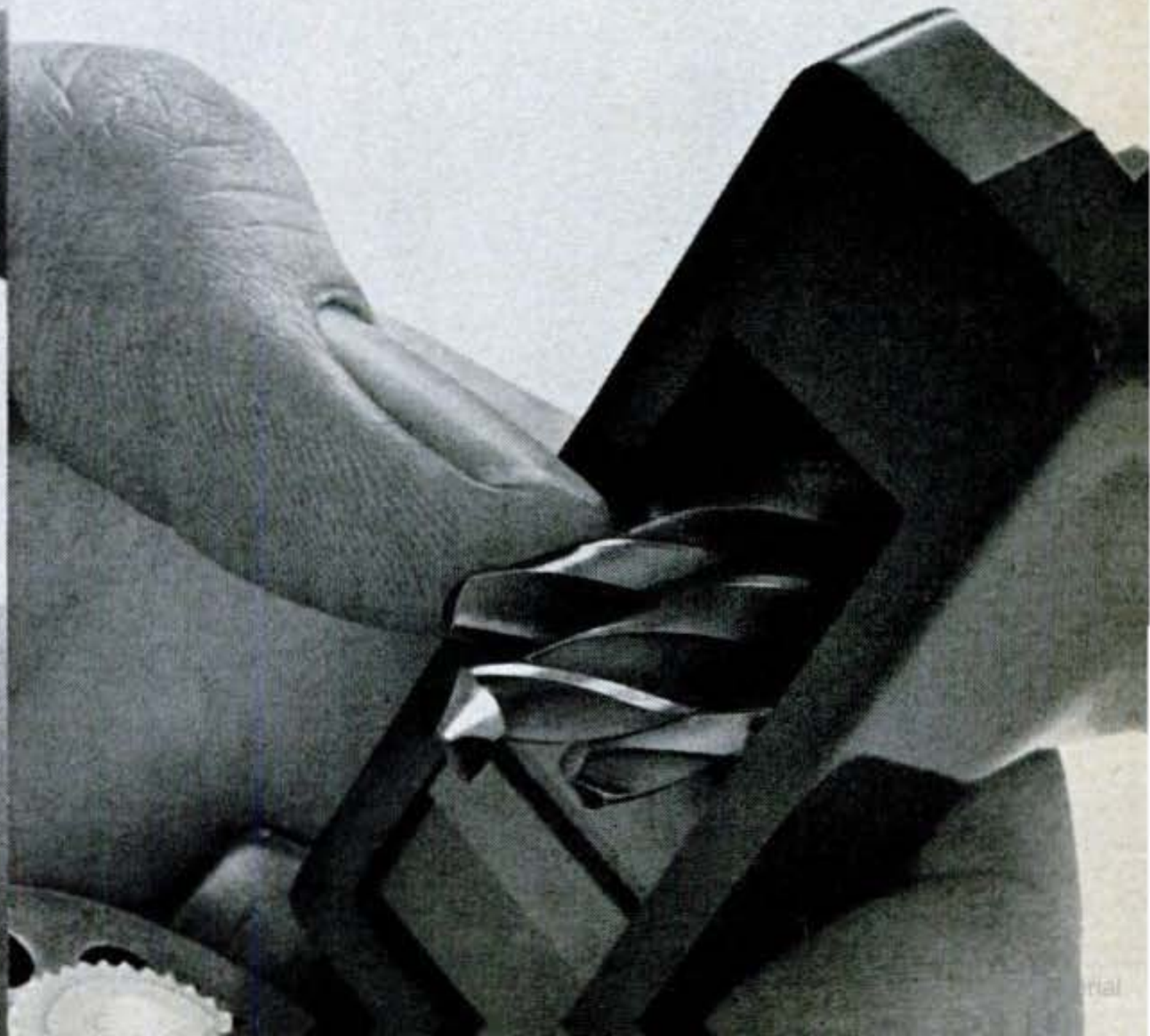
Draw a few grid lines — insert your drill bit and go to town! Drill Guide won't let the bit skitter about or mar the surface.

Handy sliding door storage in the handle keeps extra bits available. About $2.99 for a tool every drill owner will appreciate.

STANLEY®

helps you do things right



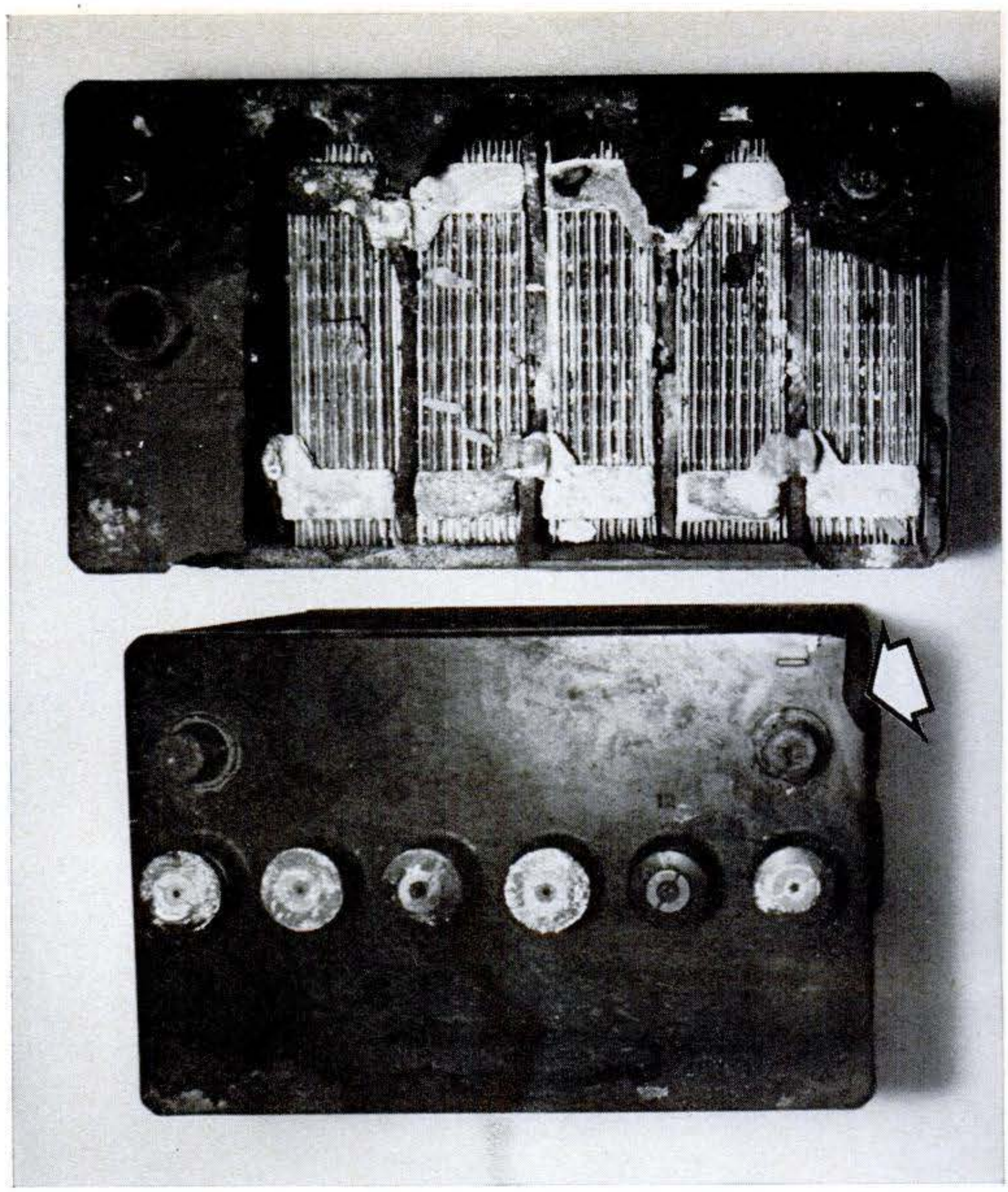


Taking Care of Your Car

Good hints others have used

Got a car tip? We pay $25 for each one accepted. Send it to Car Care, Popular Science, 355 Lexington Ave., New York, N.Y. 10017. None are returnable.

Greasing an automobile can be a slippery business. A 1½" steel washer against the coupling of your grease gun's flexible hose lets you exert plenty of pressure against the coupling when placing it over a fitting —without your fingers slipping off.



If you have a good battery—except that its case is cracked—don't try to repair it by using an open flame to melt tar into the crack. Wet storage batteries produce hydrogen gas, and an open flame or sparks can ignite the gas, causing it to explode, as the battery at top of photo did. If the case is cracked, even slightly on a corner—like lower one in photo—replace the battery. It hurts to shell out the price of a new one, but it'll hurt a lot less than a battery exploding in your face.

Too many seat belts? If your car has three belts in the front seat, and maybe a couple of shoulder-harness buckles, determining which buckle goes where can be difficult. It's easy, though, if you mark each set of belts with a different color tape.

Replacing a broken motor mount can be done without special equipment. Jack the car up, placing a 2-by-4 vertically under the engine block. Be sure the board is long enough to raise the engine about four inches when the jack is removed.

For smooth engine idle *and optimum setting* for exhaust emissions, you should reset the idle after your new car is driven 1000 miles. Why? Because a decrease in engine friction causes an increase in idle speed and a change in the idle-mixture ratio.

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TAKE OFF...STRAIGHT UP

in a Scorpion Too

Have you heard about sport flying? Did you know that you can participate in your own personal helicopter?

The Scorpion Too is RotorWay's answer to backyard flight.

Remember, the Scorpion is a true vertical take-off helicopter, it takes off straight up.

Using a 140 h.p. engine, it cruises at 75 m.p.h. and can carry over 400 lbs. The most exciting news about the twin-seat Scorpion is its low cost, but then it's about time a helicopter became a recreational vehicle.

Send $5
for complete information package including:

- 28 page color booklet containing: Scorpion development history, Rotorcraft engineering definitions, helicopter design theory, illustrated flight maneuvers (and RotorWay training program).
- Full color poster size brochure with: Description of materials supplied, description of construction plans, Scorpion Too specifications.
- Parts breakdown brochure containing: Exploded view of Scorpion Too assemblies, detailed three-view drawings.
- Complete price listing brochure.
- Brochure containing questions and answers such as — licensing requirements, etc.

. . . and a special limited offer you can't afford to pass up.

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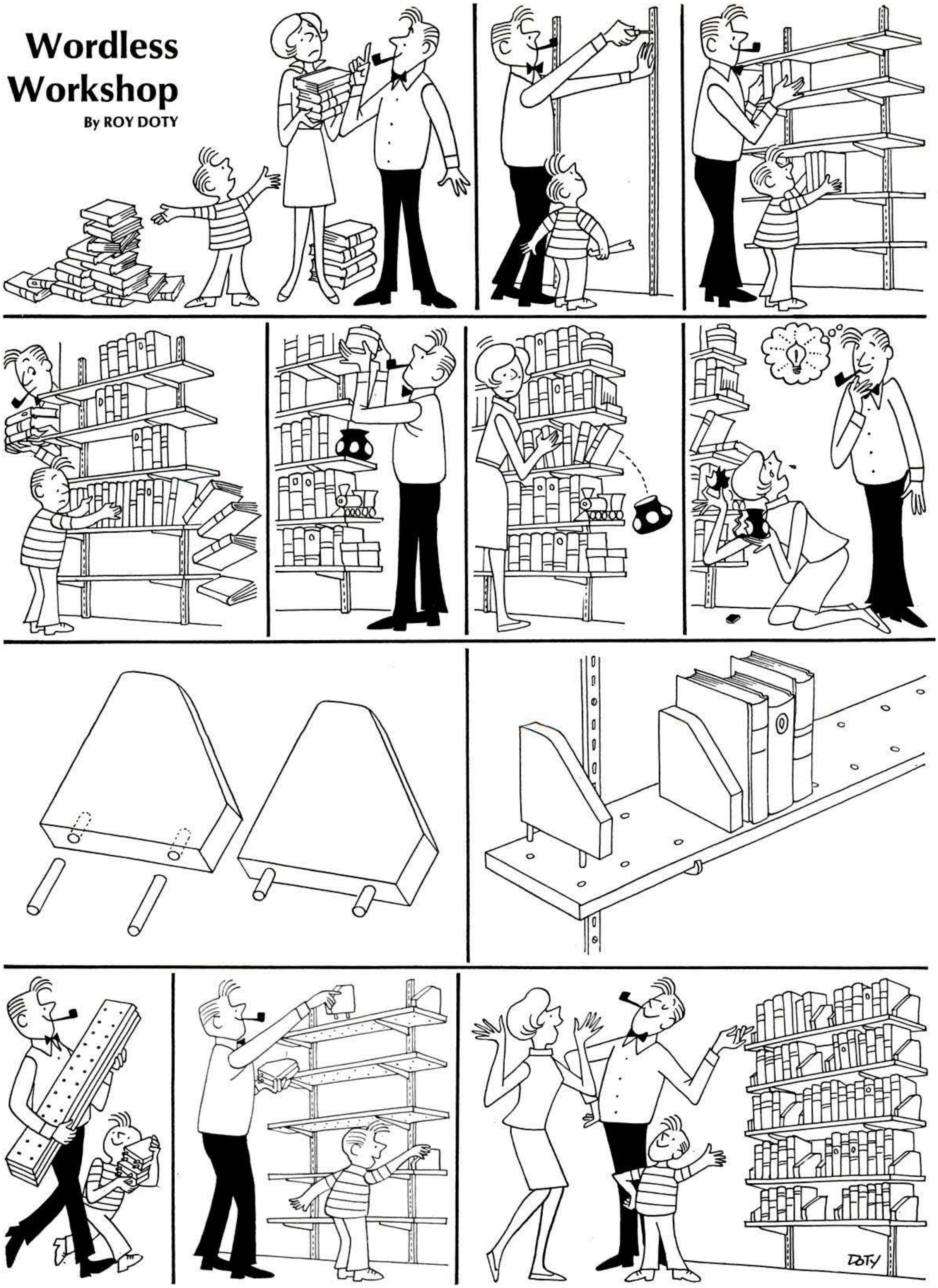
Wordless Workshop

By ROY DOTY



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Warning: The Surgeon General Has Determined
That Cigarette Smoking Is Dangerous to Your Health.
20 mg. "tar," 1.3 mg. nicotine
av. per cigarette, FTC Report Aug. '72.
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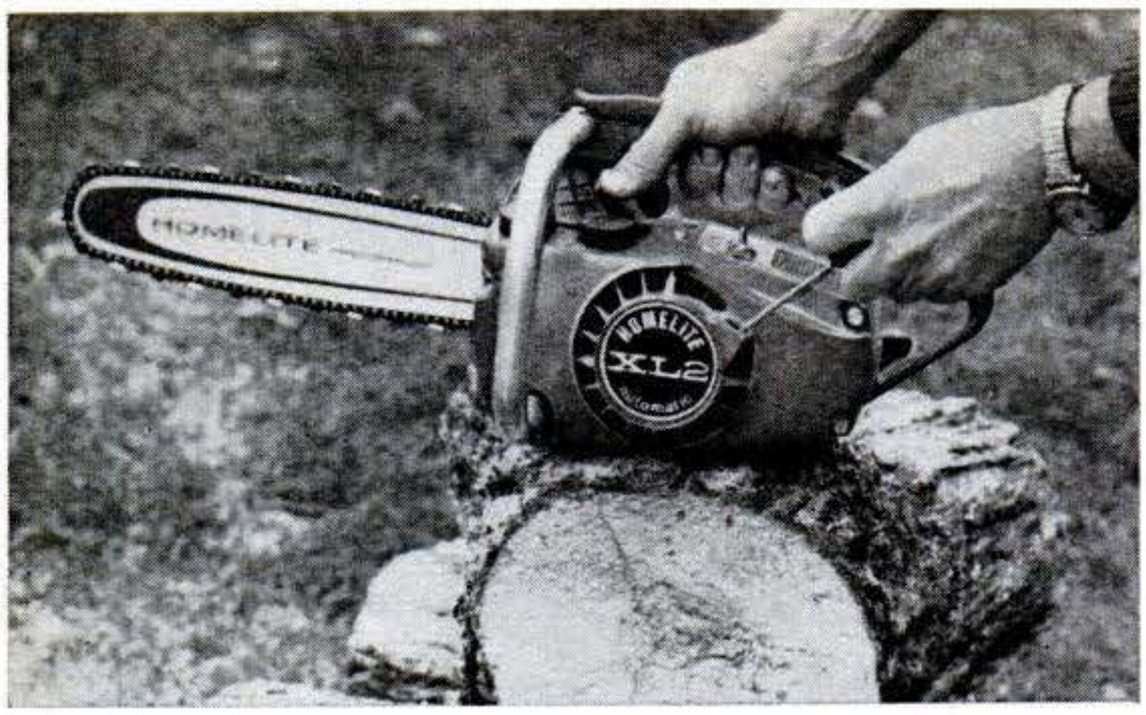

Front trigger puts your hand in perfect position to hold firmly against starter rope while thumb controls choke lever.

Rear trigger gives solid leverage against kickbacks, easy control for bucking. Muffler helps keep sawdust out of exhaust port.

PERSONAL-USE REPORT

A Tandem-Trigger Chain Saw

Two throttles on one chain saw make about as much sense as two throttles on a car—unless you're old enough to recall just how handy the old hand throttle was.

On Homelite's new XL2, some clever engineer apparently placed his hand on the saw grip right where you need it to hold against starting-rope pull. Then he located a three-position choke, ignition switch, and the front throttle so they could all be operated by one hand without losing a safe grip when you pull on the rope. On too many saws you still need three hands.

Homelite says the front throttle is also advantageous for balance-point handling under tricky cutting conditions. I couldn't confirm that—mostly because the rear throttle gave such good control. This, of course, is the point in having two triggers: the front one for safe and convenient starting, the rear trigger for maximum leverage and holding control.

Obviously, shifting your grip point would be awkward with thumb-pump chain oiling. Happily, the XL2 has full automatic oiling. Other good features are: light, all-magnesium construction (it weighs 9¼ lb. with 12" bar, gas, and oil); chain pitch ¼" (takes 5/32" file); welded hard facing on bar tip; effective, dirt-excluding muffler; piston travel on axis of guide bar.

Our XL2 started readily, hot or cold, and the bucking teeth and rear trigger made it easy to sink into a log and lever through effortlessly. At $119.95, the Homelite XL2 —twin triggers, automatic oiling, and all—is a lot of saw for the money.—*E. F. Lindsley*

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Magnition is more: alkyd-cased epoxy coils for higher available voltage at operating temperatures; non-arcing, precision molded distributor caps and rotors designed to maintain ignition system balance for all those extra miles.

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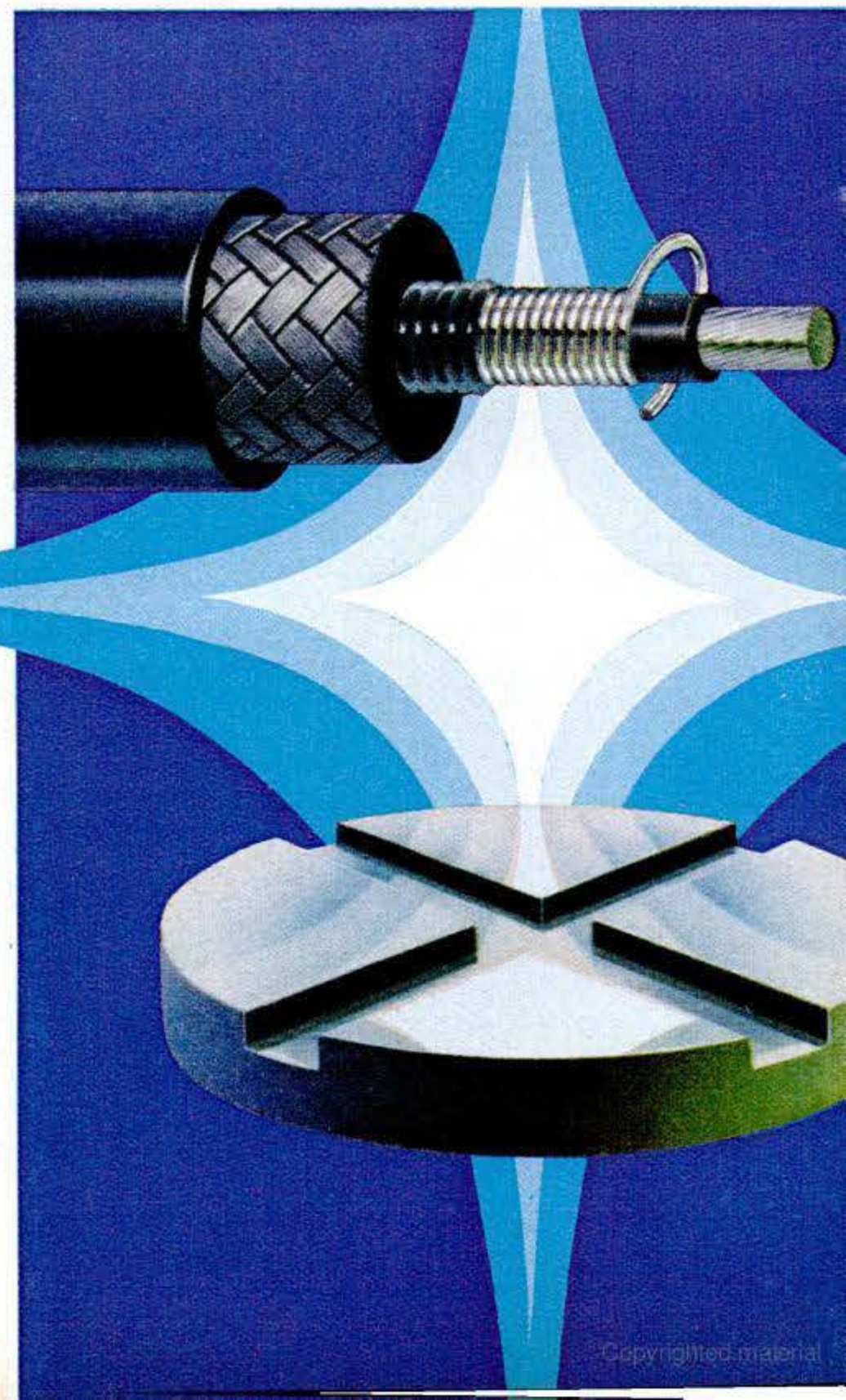

Riding the Shuttle to the Bottom of the Sea

[Continued from page 86]

Gentry assured me there would be no problem. "In the first place, this submersible has a built-in life support system of 96 man-hours. So the three of us could stay down here for a full day.

"And second, we could cut the cable and umbilical—built-in explosive cutters are ready—and bob to the surface like a cork." The capsule has a buoyancy of about 1800 pounds.

Sounds thrilling, but such an ascent isn't. At least not according to John Hopkins, who earlier had told me of his experience when he tested it from 900 feet down, off Vancouver Island.

"I was quite apprehensive because model tests indicated that the capsule would jerk and wobble erratically as we rose. So we tied ourselves down. But at the seven-feet-per-second rise we couldn't feel any motion at all—an absolutely smooth rise. Kind of disappointing."

Going down, it gets dark. The water through the port slowly changed from clear blue to emerald as we passed the 50-foot mark, then gradually got darker until at around 150 feet the view outside was black, except for a flash of silvery skin every so often outside the port.

The descent was smooth, motionless; no way to tell except that the depth gauge kept winding up—140, 230, 300 feet. No way to tell, except that I could *feel* it, feel all that pressure outside trying to get in. We stopped talking and sat listening to the low whir of the winch and the whoosh of the air.

Then, on a TV monitor that showed the view from a downward-looking camera, a circular object appeared in the spotlight, reminding me of scenes from a space capsule just before docking. We were headed for this big mouth, and were about to insert ourselves into it.

A gentle bump. And that was all. The depth gauge read 345 feet, the outside pressure, 150 psi—10 times that at the surface.

Gentry pulled a lever, and from below us pumps began to growl as water trapped between the capsule and wellhead chamber was pushed into the sea, replaced by fresh air. Through the bottom port I could see the water surface slowly lowering.

Meanwhile, probes sticking into the bottom wellhead chamber were reading air content—oxygen, CO_2, and, most important, hydrocarbons, which could be produced from the wellhead. They could be toxic. (If found, bad air would be purged with fresh.) No noxious gas was present.

Open hatch. Bell got set to spin it open and climb down to the top hatch of the wellhead chamber. Then we'd all follow to inspect the world's deepest Christmas tree. Ordinarily, that would have been an exciting moment. But for me, it was overshadowed by what happened just before it.

I was watching through the port as the water slowly lowered in the midsection, when suddenly a form broke the surface, convulsing violently in the last dreadful death throes. The water out, Bell flung open the hatch, and there lay the biggest, ugliest fish I had ever seen—a 370-pound grouper.

"Yeah, we often find them there," commented Gentry. "Crabs crawl in there for some reason, and an old grouper goes in to get them, then just sits there and waits for more."

As we tied the monster to the bottom of the capsule to take back to the surface (groupers taste something like whitefish) I saw why he had died. The suddenly decreasing pressure had caused his stomach to explode through his mouth. PS

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How to Build a Wood-Strip Trail Boat

[Continued from page 112]

the glue sets. So use a piece of cardboard or a button under the head to snug the nail against the rib, yet keep it removable. The last nail should be near the shear line of the former. Wipe off excess glue.

Numbers 1, 2, and 9 ribs have a permanent plywood center. Nail and glue the rib strips to these plywood pieces, then bend the strips around the former and nail until dry.

Let all finished ribs project 1½" or 2" beyond the shear line of the formers. They'll be trimmed later. After the ribs are sanded, put them back on the formers and put a nail in each hole. Remember: These nails will be pulled out as the hull strips go on. So, again, put something under the heads.

Clamp the stem to a block nailed to the front of the building frame. Set the gooseneck end of the stem on the frame with a 4"-long end clamped to the block. The other stem end rests in the cutout on rib #1. Glue this and nail in place.

Glue and screw the transom to the stern piece. Then place this piece in the notch of #9 rib and clamp the transom to two pieces of scrap wood nailed to the end frame (cut at 10 degrees). Measure from the top of the frame two-by-four to the transom top (it is upside down) and make sure it is 2¾". Glue and nail at #9 rib.

Applying the strips. You will need 60 redwood strips ¼" by ¾" by 18' for the hull. The ¾" face goes against the formers. Cut the strips from ¾"-thick boards at least 18' long. Pick clear, straight-grain boards. Heft each one and pick the lightest ones.

Place the first strip along the shear of the hull. Make sure that the top (remember that the hull is upside down) of the strip lines up with the shear line of each former. Glue and nail it at the two #5 frames with ¾" #15 bronze "stronghold" boat nails.

At each rib, hold the strip in place and drill a 1/16" hole through the strip and into the rib (to prevent splitting). Then nail. On the first strips, locate the nail high on the strip, because you'll later drill a hole in the center. As the strips bend in toward the stem and stern, you will see that they do not lay flush against each rib. The gap can be filled with resin later. At these ribs, try to drill and nail at 90 degrees to each strip.

When the first strip is in position against the stem, you can judge the angle the stem must be cut to let the inside of the strips lay flush. Draw a centerline down the front of the stem and use a saber saw to cut the angle. Sand with a disk to get it exact.

Now glue and nail the first strip at the stem and transom. Cut the end of the strip at the same angle as the opposite side of the stem, so the first strip on the other side will lay against this sawed end. Then, after the first strip on the second side is glued and nailed in place, cut it off at the stem at the same angle and flush with the outside of the first strip.

After one strip is on each side, run a line of glue along its top edge and dab some on each rib where the next strip will touch. Lay the next strip in place and nail at the two #5 frames, then work toward one end, drilling and nailing at each rib as you go. Overlap alternately at the stem in groups of three or four as shown in the drawings. When up to four strips are in place, put a spring-type clothes pin on top and bottom strips and wind a rubber band around the two pins to squeeze them together. Wipe off excess glue.

When one set of strips has been clamped and cleaned, go to the other side and do the same. You will note that the stern sticks up beyond the 24th strip toward #9 rib. Glue a short piece of redwood strip on each side of the stern on top of #24 strip, then blend it in with a sander.

With the hull closed in, sand it smooth. If any edges protrude, use a small plane to cut them flush. There should be a dip of about ¼" at the hull centerline between the #2 and #1 rib. It is part of the design to make the boat faster and dryer.

Glassing the hull. The original boat was covered with Vectra cloth because it is lighter and stronger than fiberglass. We found that using a power sander to feather overlapping edges caused the Vectra to melt. This defect does not disappear under the next coat of resin as it would with fiberglass. If you plan to paint your boat, Vectra cloth is a good choice. If you want a natural wood finish, we suggest fiberglass. We also used Valspar Boat Armor Resin; it's an iso—easier to use than epoxy.

Lay the cloth along the center of the hull so that about 2" extends beyond the centerline. This will give 4" of double thickness along the keel. Staple the cloth in place. Rub out the cloth along the hull so it lays smooth. Mix a quart of resin and start at the keel at the center of the hull and work toward each end.

When the first side is covered, wait for it to set up. Then feather all edges along the keel, stem, and stern, and pull out all staples. Lay the cloth on the second half, overlapping about 2".

When the resin has set, trim the edges with a sharp knife and feather overlapping edges along the keel, stem, and stern. The transom can be covered with separate pieces on each side or by using one piece. Be sure the cloth overlaps around the edges to the sides of the hull. Sand the entire hull, especially all sharp edges, points, and overlaps. Then give the hull another coat of resin—the last.

When the resin has set up, turn the hull over on a pair of horses. Cut a 4"-wide strip of cloth and set it in with resin down the centerline between each rib on the inside bottom of the hull to reinforce the keel screws.

If you want a light boat, this is all the cloth you need inside—just give the inside a coat of resin. But for a stronger boat, put cloth and resin up to each shear between each rib.

Keel, clamp, and rub rail should be of hardwood. Cut the ¾" square keel to fit snugly between the two stem pieces left sticking from the bottom. Drill for ¾" #10 screws through the hull—just ahead of each rib forward of #5 and behind each rib astern of #5 on the hull centerline. With the boat upside down, have someone hold the keel in place while you drive screws into the keel from inside the hull.

With the hull right side up, cut the rub rails ⅝" by ¾". They need not be more than 9' long because they will be cut between the two #5 frames. Also cut the ½"-by-¾"-by-9' clamp strips. With a friend helping, bend in the rub rails and clamps on both sides at once so as not to twist the hull.

At each rib, drill a 3/16" hole through the rub rail, rib, and clamp, countersink the hole on the rub rail side, and bolt with a #10-24 flathead brass or cad-plated bolt 2" long. At #5, drill the hole 2½" forward of the cut-apart line through the rub rail, planking, spacer, and clamp. Here it will not interfere with the ¼" holes that hold the hull clamps in place. Follow the same procedure on the stern half. At the transom, pull the clamp strip to the planking.

After the keel, clamps, and rub rails are installed, turn the hull upside down, support the center (#5 frame) and the two ends firmly. Cut the hull in half on the lines you drew as you put on each strip.

After glassing the cut ends (each #5 former), cut a 3"-wide strip on the bias from leftover cloth and stretch it around the edge, overlapping both the #5 former and the hull side. Give this a good coat of resin. Sand when dry, blend all edges smooth (feather), and give both surfaces another coat.

You need three clamps to hold the hull sections together. You might have these made locally if they're be-

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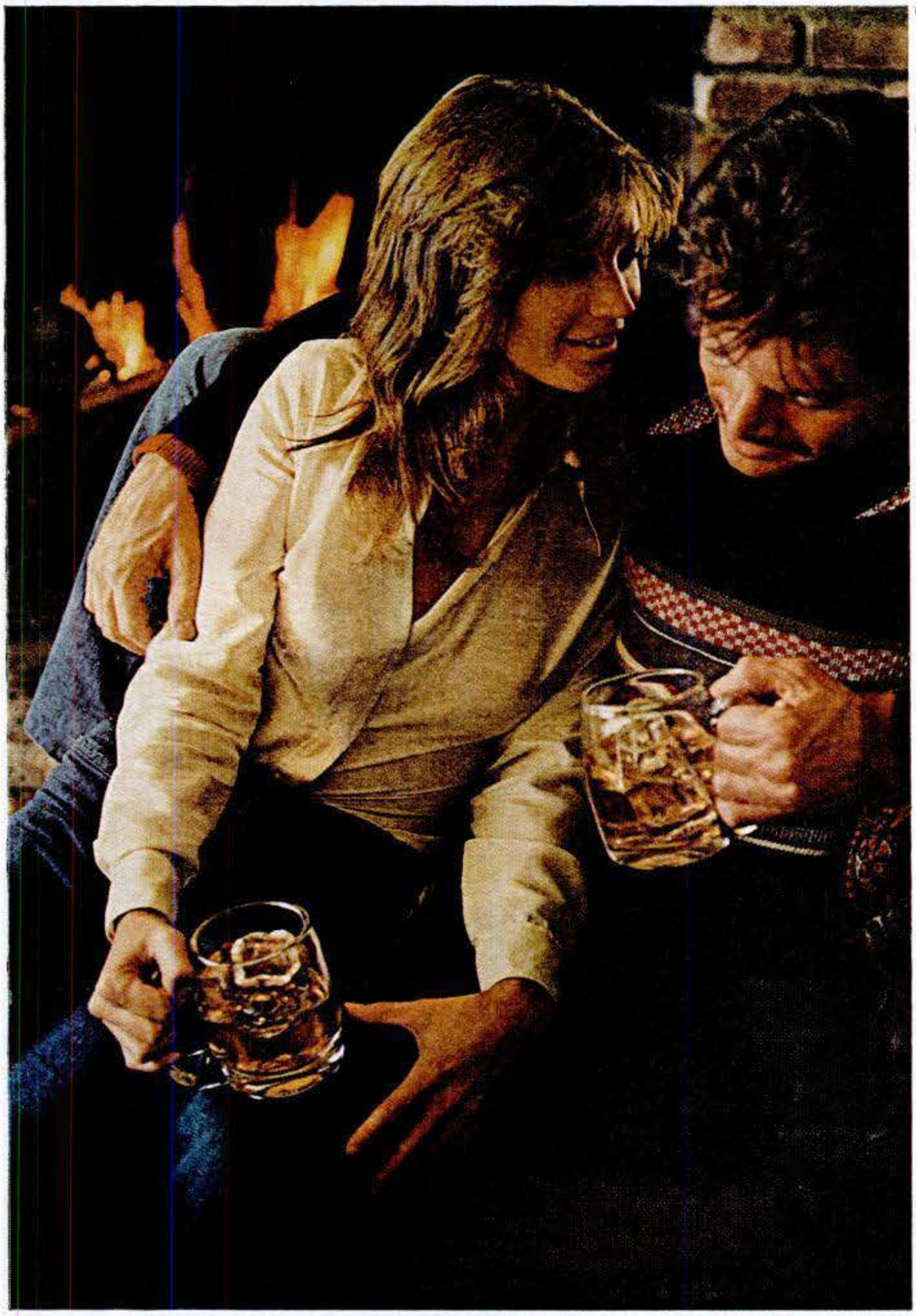

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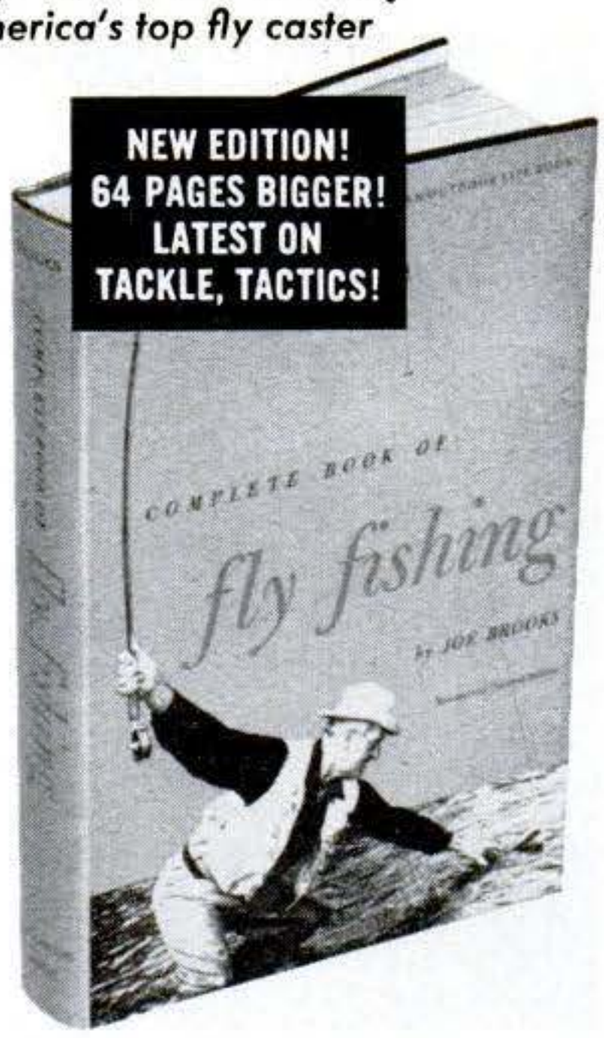

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Wood-Strip Trail Boat

[*Continued*]

yond you. Otherwise, order as indicated in the materials list.

Clamp the two boat halves together again, lining up the keel and rub rails exactly. Cut the keel to receive the hull clamps, being careful that the clamps go in flat and easy. Drill ¼" holes through the keel and hull. Push two ¼"-20 flathead bolts 1½" long through the holes, place the ¾" angle (see hardware drawings) over the bolts inside the hull, put on nuts, and tighten. Do the same on the other half. You should be able to slip the spring toggle pin through the clamp now, leave it in place, and turn the boat right-side-up to install the two side clamps in the rub rails.

Bolt on these clamps with ¼"-20 flathead bolts 2½" long through the rub rail, planking, spacer, clamp and angle plate. When all three hull-joining clamps are in place, take the hull apart and drill and bolt the angles through the two #5 frames with ¼"-20 flathead bolts 1" long (¾" will do, if you can find them).

With the hull right-side-up, level it sideways and fore and aft to install the seats. Set the seats on rails that span from one side to the other. Check the seats with a level.

The oarlock sockets are placed astern of the back edge of each of the two rowing seats (front seat and middle seat), and one oarlock socket is as near the port stern as possible, to take a rudder oar. Bolt these through the rub rail, hull, ½" filler blocks, and clamp, using ¼"-20 flathead machine bolts 2" long.

Lay out oar blades from the drawings on ½" plywood and cut them out. The shaft is made from 1¼"-dia. closet pole. Cut the short piece that attaches to the blade and slot it ½" wide 4" long to slip over the blade at one end. Make sure the grain is 90 degrees to the blade. Turn the other end down so that a 4" piece of 1⅛"-I.D. aluminum tubing will press on. Drill a ¼" hole 1⅝" from the end through the center of the tubing. Cut a slot ¼" wide from the hole to the end of the tubing. Glue and nail the shaft to the blade. Sand the blade edges to a good shape and give it a coat of varnish or resin.

Fit to the bottom end of each handle section an 8"-long 1¼"-I.D. piece of aluminum tubing pressed for 4". Pin in place 2½" from the open end by drilling a ¼" hole parallel to the grain of the dowel. Put a ¼"-20 carriage bolt through, add a wingnut.

For the oarlock, drill a 3/16" hole through the handle 90 degrees to the blade and 17½" from the handle end.

NEXT MONTH: Adding a sail. PS

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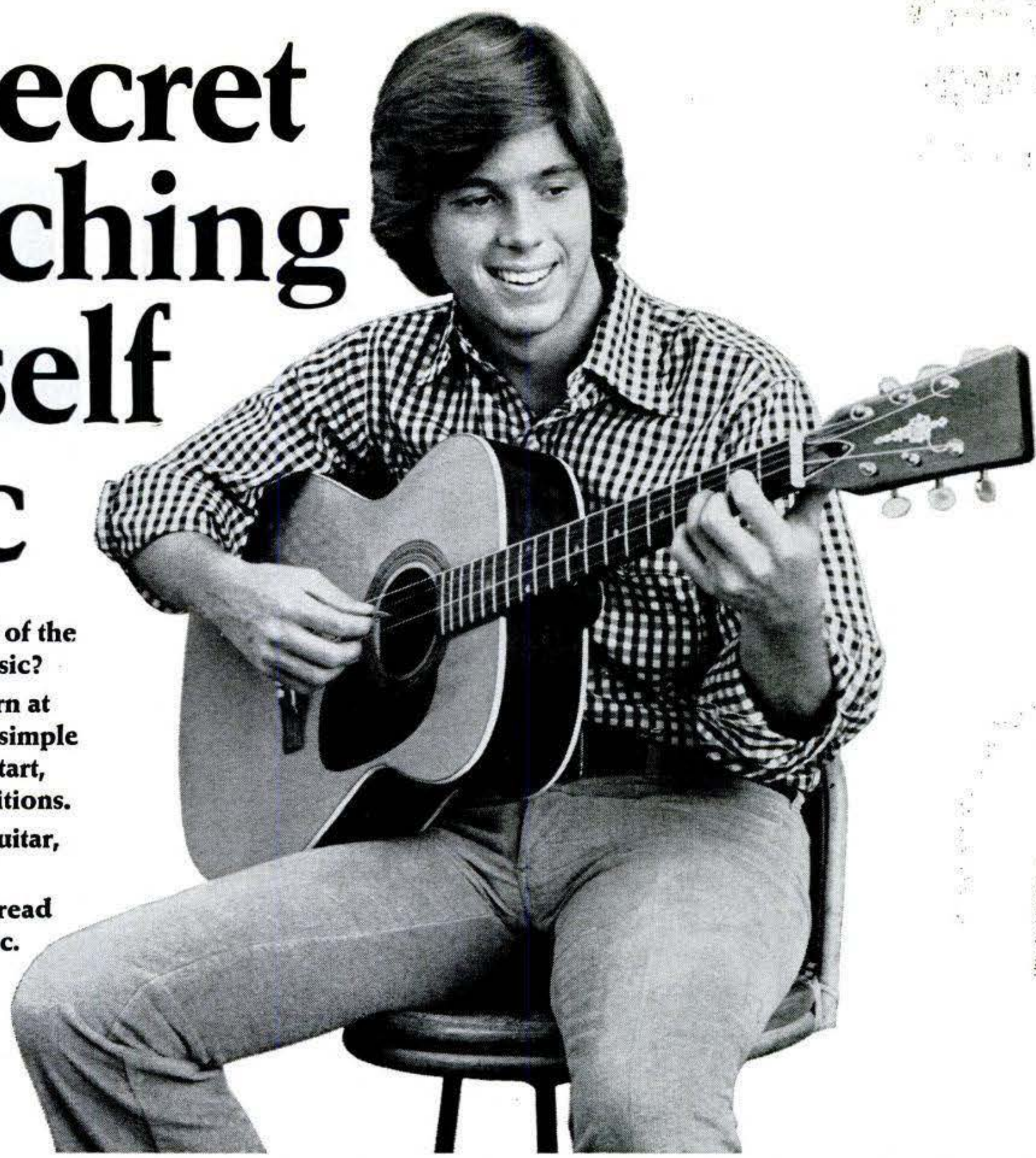
The secret of teaching yourself music



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Others also enjoy her playing, Mrs. Johanson reports. She plays for herself to relax after a trying day, and for her husband when he's tired. She also plays for friends when she goes to parties. "In a sentence," she says, "it's the most soul-satisfying thing that has ever happened to me."

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Through a Lightning Storm in an Outboard

[Continued from page 121]

other boat (as we did) if you're in an open outboard, and getting across before midday storms kick up. By 10:30 our blithe chop had grown to three-foot waves pushed by west-northwest wind. A well-defined cumulonimbus (thunderhead) was building up over South Cape as we arrived. But since it was due north of us, we dodged it by heading west toward Cape Sable.

Joe G. still missed the big fish he had on the line the evening before, so we turned into the south fork of the Shark River, a broad flowage in one of the most wild and primitive parts of the Everglades. With a sandwich in one hand, a spinning rod in the other, Joe caught a 10-pound grouper that doubled his rod and towed the boat up-down river before it gave up.

We shouldn't have hung around. But the Everglades had got to us all. We watched iridescent ladyfish, and crevalle that swim as swallows fly—and are more beautiful. A great white heron waded in the shallows, flamingos and pelicans jabbered across the river, overhead an osprey attended beady-eyed to our fishing. Small-animal sounds came out of the cypress forest, and occasionally we heard a crash in the distance—maybe a white-tailed deer, black bear, or panther.

We finally beat it when we realized the sun had disappeared. We'd be lucky now if we reached Marco without running into a squall. Outside, the sky had turned a sickly sand color, altostratus clouds streaked ahead, and the temperature dropped. It didn't feel exactly like fun any more, and I wished we were in port. Jesse broke out rain jackets and put up the full bow cover and the umbrella top over the helm station. He's a good sailor. My morale lifted as the top went up

A great storm array was building up to the east, with still greater crowns as much as 20 miles behind the front. First came short flashes of probe lightning that lit the tops of clouds. Then fissures of streak lightning—prying, burrowing with grunts through heavy cloud layers, and with terrific splitting sounds finding the way (against great electrical resistance) to establish an abundantly ionized conducting path to earth.

But why from the *east*? The weather system at Cape Sable at noon had been west to east, with slender north-south depth. I expected that a four p.m. attack, if we couldn't steer around it, would come off the Gulf.

The answer, of course, is that local wind systems are the rule on the South Florida coast. Storm clouds here form on the line of the coast, in whatever direction it runs.

Now a roll cloud of the advancing storm's foot hooked out in front of us. Lightning popped in the water only a few hundred yards away. I savvied, then, we'd run into more adventure than I wanted. Boat-shaking downdrafts hit the canvas, but it held. Golf-ball-size raindrops splattered the view, hit my face, wiped out the shore.

The lightning vanishes. Small hail soon replaced rain, and while it hailed, there was no lightning. Deprived of a reliable conducting column? We breathed well for two minutes; whereupon we were outrageously doused with a sheet of water. I glanced shoreward in fright, thinking we had stumbled into the breakers. But we were still marooned in a tiny circle of sea, like inside a washing machine, all a chaos of splashes.

Fact was, a continuous stream of water was falling on us from a cloud. Not just *like* a stream, but rain joined in a column. So great was the updraft pressure in the primary rain area of the cloud, apparently, that it caused a waterfall column. This would constitute a surface-charged superconductor for lightning—God knows why it didn't strike us in the several seconds it lasted.

Ninety-mph gusts hit immediately afterward from 360 degrees. The boats pitched like seesaws, and because we couldn't anticipate, we couldn't brace ourselves for the blows. Though none of us was seriously bruised or injured, it was physically punishing and exhausting, not only emotionally.

The boat was abler in this situation and took better care of us than we could manage. The blessed motor went on doing its job when everything else blanked out.

About then we saw Bud's boat for the first time in 15 minutes, much farther away than expected. It was making slow headway toward the mangrove shore that semicircled ahead. We were in Gullivan Bay, just south of Marco, and inside Cape Romano to the west.

Bud was alone on deck. Legs planted wide, the boat lurching and twisting. No sign of the others. We hoped they were still aboard, safe under the bow cover.

Suddenly both boats were in a shooting gallery of lightning. It was striking too near on all sides. No sight warning—just that terrible rocketing sound . . . boom!

Bud was hit. I'll try to reconstruct what happened from what all of us took in:

First, the biggest bolt struck some 30 feet away from Bud, and several hundred yards ahead of us. Bob Stearns was looking out of the bow curtain right at it—it looked as big as a tree trunk, he said. The sound? It came down like a chain, a paralyzing staccato almost inside your head. Then an unbelievable explosion.

A fraction of a second later Bud lit up with St. Elmo's fire—a corona discharge. There was a psychedelic blue all around him before it discharged on his forehead dome—it felt like a hammer blow, he says—and exploded in his ears.

"I went into sort of neutral. I couldn't think or feel momentarily," Bud says. "I remember holding onto the steering wheel, trying to get up and sort of falling down. I went through this big thing for a moment until I realized I was still alive, I had survived it.

"Then you remember it started to roll like hell, and I was concerned because there was no real reason for terror, but some people not used to storms like this become terrified, and that's why I motioned to your boat. I don't know how coordinated my actions were.

"I must say that I had a bad headache and bloodshot eyes for about three days."

It's certain he had not been struck by cloud lightning, with charges probably running from 10,000 volts per centimeter to much higher. Doubtless it was a positive discharge from the unusual buildup in the area.

Well, that was the end of the storm. It had shot and blown itself out. In 30 minutes we were in harbor.

How's Marco? The island is a community built around boating and fishing, so we came easily to roost. Our two boat crews sat down for dinner that night at the Marco Beach Hotel, which is delightfully full of the comforts our shaken selves needed. Fans talked across tables to Joe Garagiola. Bud Kirk really glowed with a bright red burn, astonishing us who were accustomed to his deep, weathered tan; we realized he had a lightning burn.

Advice to visiting boatmen. Most important for skippers setting out to do what we did is to proceed slowly. You must be able to anticipate 500 yards ahead at all times. Then you'll avoid running aground on the flats, or missing the cut in channels. Get frequent weather reports, and watch the sky and sea signs. Be ready to change course promptly—you can often dodge a storm. You're almost always in sight of land on this run. Markers, radio, and positive-flotation boats have really taken most of the danger out of it. PS

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How Science Wages the Fight Against Fog

[Continued from page 78]

encapsulation process, applied to urea, provides thin shells for the fragile, moisture-absorbing crystals so they can be used as a warm-fog seeding agent.

Tests with urea. In tests over McClellan AFB in California, the urea capsules cleared a large area of fog. But shifting winds made clearing a specific target area very difficult. With any air-seeding technique, turbulence and wind shear play a critical role. With general wind direction known, a patch of fog can be seeded upwind, timed for dispersal when it reaches a runway complex. Large areas can be cleared this way when CO_2 is used for supercooled-fog dispersal; but the job would become very expensive with urea on a large scale.

An intriguing fog-dispersal technique using helicopters has been used to rescue people in fog-shrouded areas of Viet Nam. A big helicopter hovers or flies in clear air over the fog layer. The rotor-blade downwash pulls relatively dry air into the fog. The mixture becomes subsaturated, and the fog droplets evaporate. In tests, copters cleared areas and landed in fogs less than 300 feet deep. On two occasions, a test helicopter cleared a 6000-foot runway.

Ground-based fog dispersal. One method for clearing warm fog is to apply large volumes of heat to evaporate water droplets. The British had the FIDO (Fog Investigation and Dispersal Operation) burning huge quantities of oil during WWII. The technique was also used at Los Angeles Airport from 1948 to 1953, but was abandoned because it was too expensive and air polluting. And, open flames presented a hazard to landing planes that might slide into them.

Underground jets. More recently, other heat sources have been developed. At Orly Field, the French use exhaust heat from underground jet engines to evaporate warm fog. It works, but it's noisy, and air polluting, too. There's also a report that the jet-exhaust turbulence causes landing problems for small aircraft.

In 1968 the Air Force, following a similar test in France, tried dissipating warm fog at Travis AFB, Calif. Four giant four-engine Starlifter transports were spaced along the runway 750 feet apart. The 16 jet engines were operated at full power for three five-minute periods in dense fog. Visibility increased from less than ¼ mile to over ½ mile, and the clearing lasted as long as the engines ran. This is an expensive way to clear fog, but it demonstrated what could be done in an emergency.

Burning liquid propane. A more promising development is being studied under Air Force sponsorship. The heating system involved depends on the controlled merging of heat plumes generated by numerous enclosed liquid-propane burners.

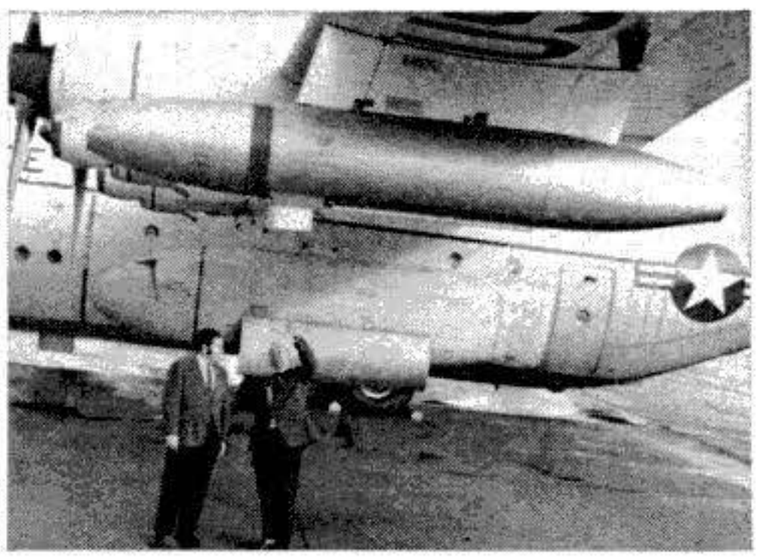
First proposed by Dynamic Science, Inc., of Irvine, Calif., this technique promises to be efficient, noiseless, smokeless, and safe for landing aircraft. Dr. Silverman points out it should be possible to use natural gas where it's available. Cost estimates for such heating techniques range from $300 to $1500 per plane landing, based on five minutes of fuel burning.

Another ground-based approach, for cold fog, uses liquid propane in a different way. The propane is sprayed into the fog as a mist. This chills the air much as dry ice does, and the fog settles as snow.

In the Air Weather Service operations, the LP is dispensed from pressure tanks around the runway. Five or six located upwind are turned on an hour before an expected landing or departure and left on until flying operations are over.

Money-saving dispersal. Results of this system, according to the Air Force, have been equally as effective as the airborne system. It has been installed at Anchorage, Hahn AFB in Germany, and at Fairchild in Spokane. Already it has saved hundreds of thousands of dollars for the Strategic Air Command. The Fairchild installation cost $40,000 for operation, compared to roughly $350,000 for one season of airborne operation at Elmendorf (without adding the cost of planes, already available).

In a contract with Gourdine Systems, Livingston, N.J., the FAA is evaluating a method of clearing warm fog in Panama: embedding 6500 spray guns along a runway to spray out water droplets charged by high voltage. The high-speed particles would become attached to uncharged fog droplets and grow into rain drops. PS



Unique raindrop spectrometer in pod under the wing of C-130 can measure size of water droplets before and after cloud seeding.

Fantastic Computer Pictures

[Continued from page 105]

thus presenting the star data in a more understandable form.

Molecular plots. Prof. Don McLaughlin of the U. of New Mexico used 3-D plots to produce movies of a chemical reaction. "Most people think of chemical reactions in terms of pouring liquids from one test tube into another. But the real reaction occurs down at the molecular level where atoms are colliding with each other," says McLaughlin. "By watching the progress of a chemical reaction in a computer movie, new effects can be detected that would otherwise never be seen in a still picture."

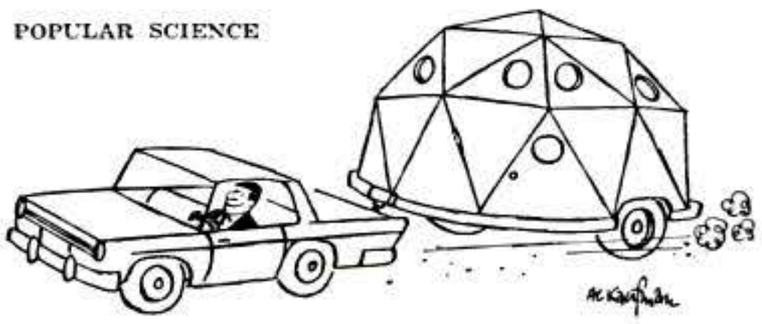
Air Force Major Francis Kieltyka said, "It's very interesting to watch a mountain grow, and then be able to walk around it to look at interesting irregularities and hot spots."

He wasn't referring to volcanic mountain-building. He was talking about fluorescence in the ionosphere, that part of the Earth's atmosphere from 25 to 250 miles out. High-flying rockets lofted into this space region carry packages of fluorescent materials that burst and scatter the sparkling particles over a wide area.

Earth's magnetic force. The particles tend to follow the Earth's magnetic-field lines, and tracking instruments record tons of data. PICTURE drew a mountain with the data and helped the major and his fellow researchers "see" the patterns of magnetic force. Their work is centered on solving radar blackout problems.

PICTURE is new and still confined to laboratory research programs. But many practical applications are possible. One vital area—pollution—could be plotted to show analysts smog buildup around heavily populated cities. Rivers and watersheds drying up could be pictured and studied more readily; also, the movement of silt down main waterways and its buildup against flood-control dams could be plotted. Practically everywhere that people gather statistics or put numbers together, a PICTURE-like plot is useful.

One can imagine the satisfaction of mathematicians everywhere now that they no longer have to say: "Picture this function in your mind." All because computers can draw, as well as print, columns of figures. PS



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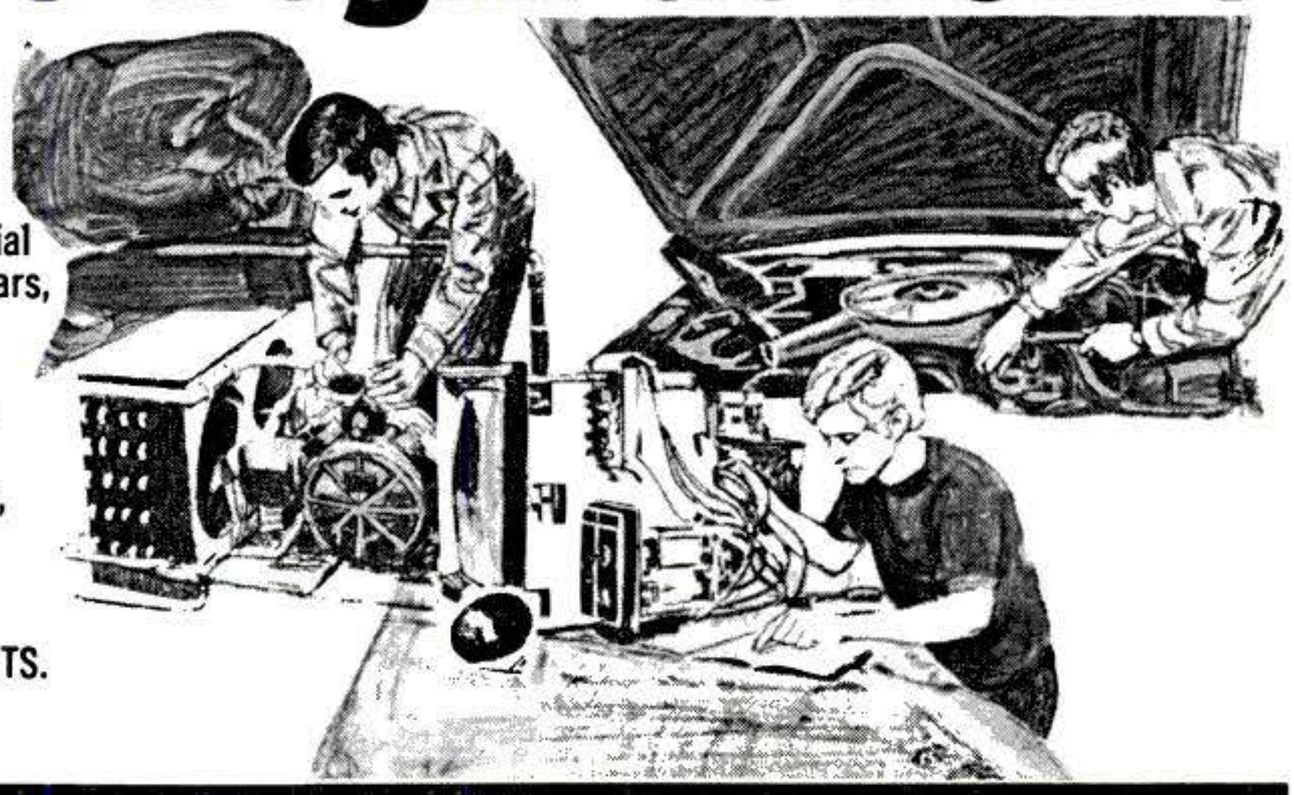

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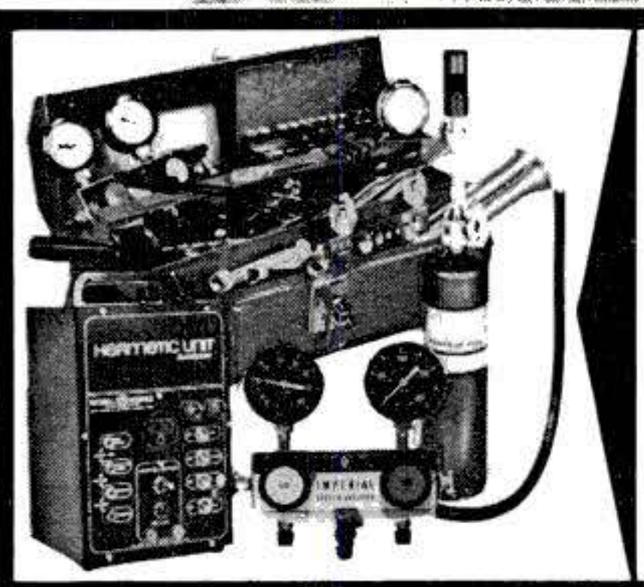

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Ford's Stirling-Cycle Engine

[Continued from page 75]

needs of the complete engine. Philips may have the second problem solved.

"Some of these techniques have to be invented before we can go into production," says Collins. "It is not a big problem. We just have to find the best way to do them in mass production."

How does the Stirling stand among the other alternative power plants at Ford? "Right now it has as good a chance as any other," Collins says. "We are further ahead on the gas turbine and the Wankel, but none of our '75 and '76 test engines has passed the 50,000-mile standard. Until then, you can't say any one is the front runner."

What of the future? With the end of some fossil fuels in sight, it's only to be expected that Philips should consider alternative heat sources for the Stirling engine. Hydrogen fuel [PS, Jan. '73] is the most obvious answer. "I'm convinced hydrogen is the fuel of the future," says Dr. Meijer.

Dr. Meijer points out that Euratom (the Common Market's Atomic Energy Commission) has invented a closed chemical cycle for extracting hydrogen from water without electrolysis by adding heat. For this process Euratom claims an efficiency of about 75 percent. "Once such a cycle is mastered," says Dr. Meijer, "the heat liberated in nuclear reactions could be used directly to produce hydrogen on a mass scale."

For the Stirling car of the future, Dr. Meijer sees the possibility of an on-board hydrogen accumulator, working under low pressure (1 to 2½ atmospheres) at ambient temperature. He suggests that hydrogen could be absorbed in some solid material, granular or particulate, for all kinds of storage.

Absorption and liberation of hydrogen can be easily regulated by temperature control (it takes heat to liberate hydrogen, while hydrogen absorption creates heat).

However, a general switch to hydrogen fuels in the future can be made without adoption of the Stirling engine. In the view from Eindhoven, the chances for the Stirling are predicated on two conditions:

1) That the Environmental Protection Association will maintain the stringent emission limits for 1976 and beyond.

2) That the Ford Motor Co. will decide on the Stirling for its main thrust in meeting future emission standards.

If both conditions are met, the only question that remains is how much it will take to get the Stirling out of the lab and onto the road. PS

PS Guide to Life Jackets

[Continued from page 118]

Once you have your personal flotation gear on board, you'll have to perform very little maintenance; but there are a few tips to remember. Don't keep your PFD's in plastic bags under any circumstances. (Let them get dirty if you must.) Besides violating CG law, it could cause condensation and lead to mildewing. If you use your PFD, let it dry out in open air. Never stow it away wet.

If you own kapok vests, be especially careful when checking your gear. "There are many ways that the plastic bags can rupture and get waterlogged," says Kent Flowers. "Yet it's simple to inspect the equipment as often as you go boating. The whole thing takes maybe 15 or 20 seconds." Make sure the straps haven't rotted; a few quick tugs will test their strength. Snaps shouldn't be rusted.

Be sure your PFD's are stowed in "easily accessible" places. If you tuck them away in the bilge, you may not have them when you need them. One suggestion is to designate one locker strictly for PFD's. Then label it, just as they do on ocean liners. If you're unsure about where to stow them, a CG representative will be glad to help you. Free courtesy examinations are encouraged by the Coast Guard Auxiliary; and there's no penalty if they find something amiss. However, if you wait until they board (much like a police car stopping you for a routine check), and then they discover a violation, you could be in for a $100 penalty ($500 under the new law).

A final suggestion: When you have your neighbor out for a day's fishing, show him where the PFD locker is, take one out, and have it adjusted to fit him. "You may get laughed at once, but you'll earn his respect," says Capt. Mitchell. "The last guy that had it on may have had a 28-inch waist; this guy 48 inches. Two minutes to try it on may save his life." PS

Type III flotation devices are not designed to turn unconscious wearer face up, as demonstrated here. But you get biggest choice of size and style.

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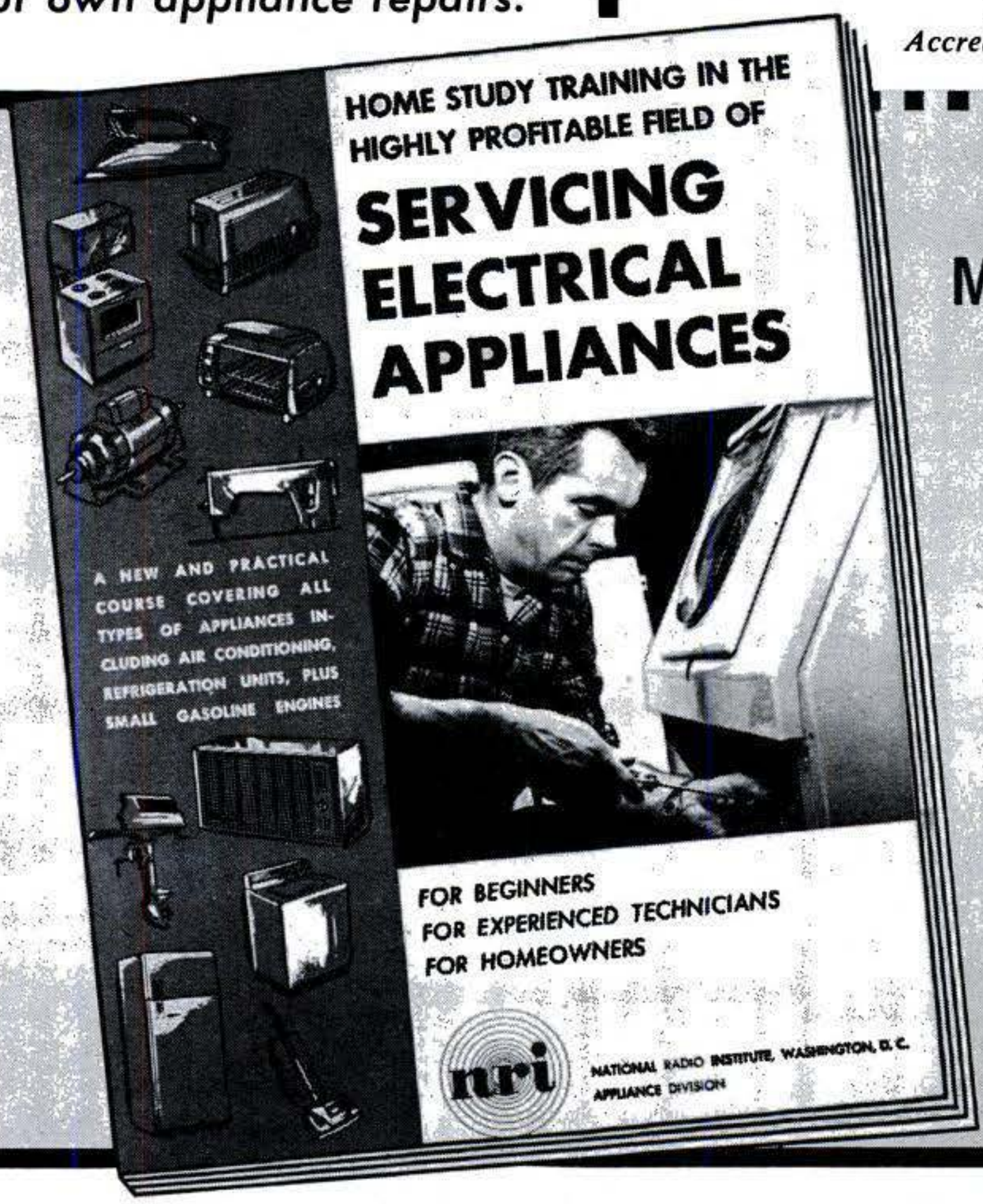

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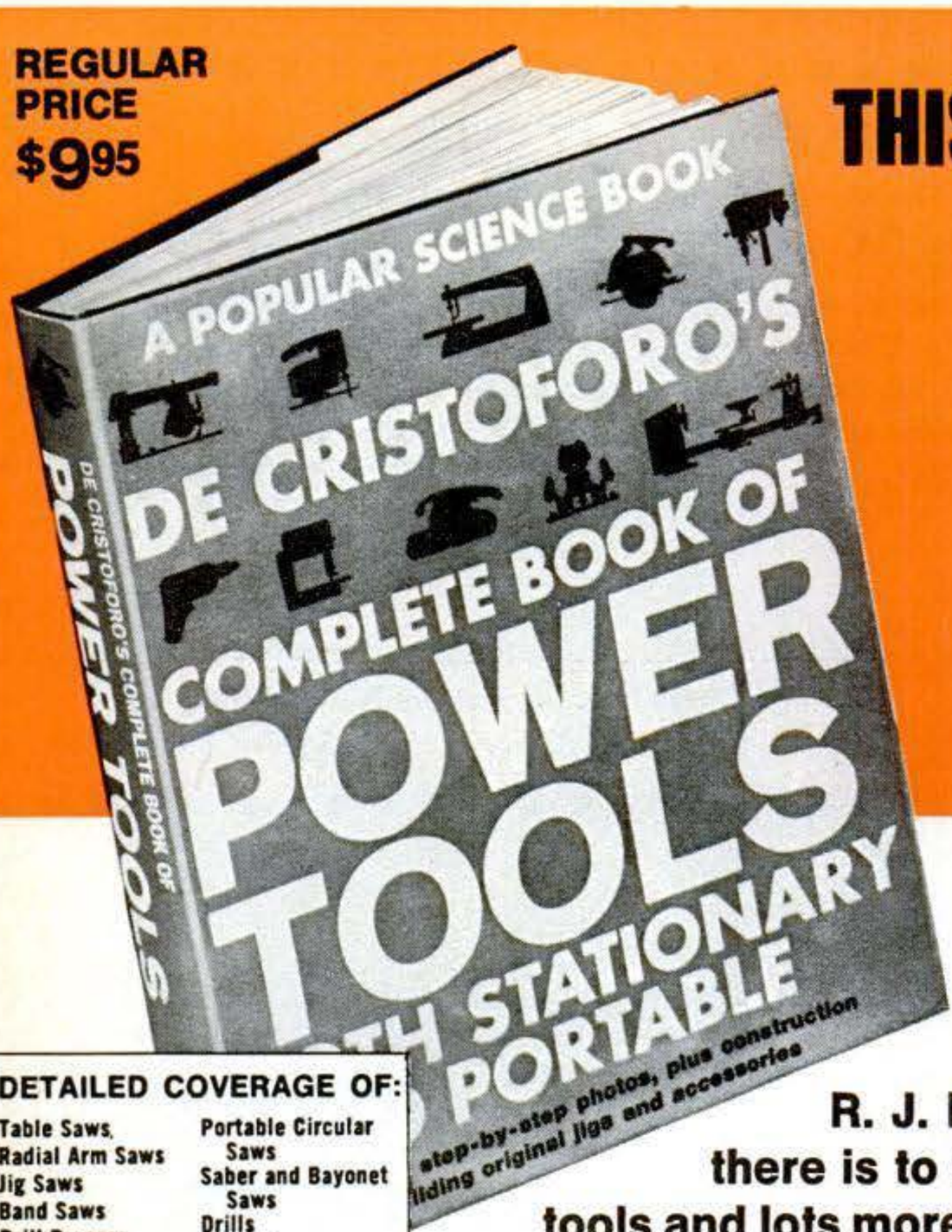

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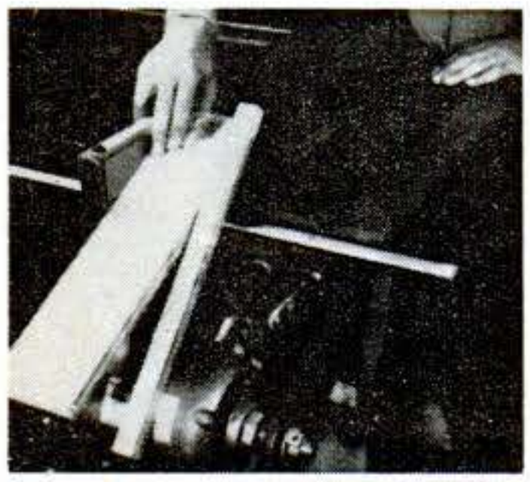
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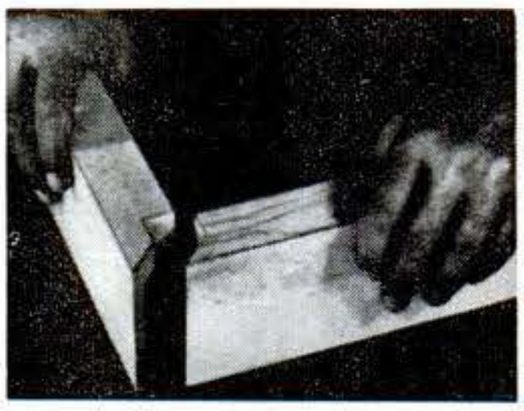
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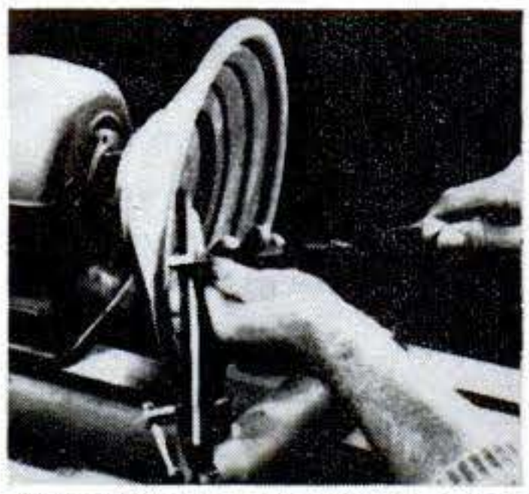
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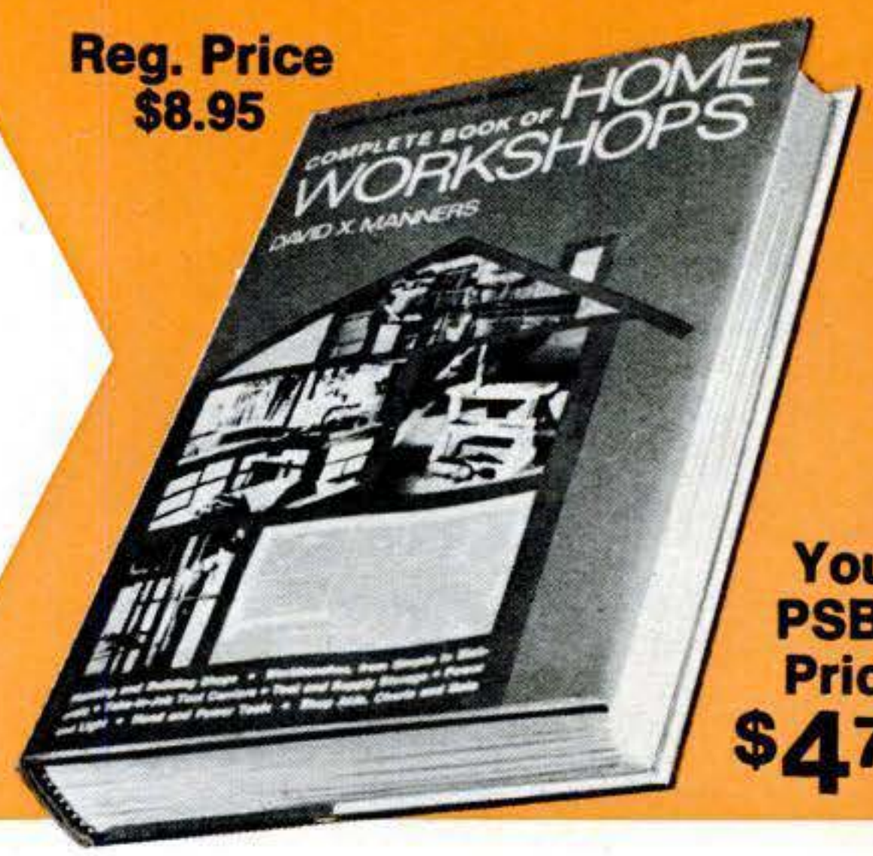

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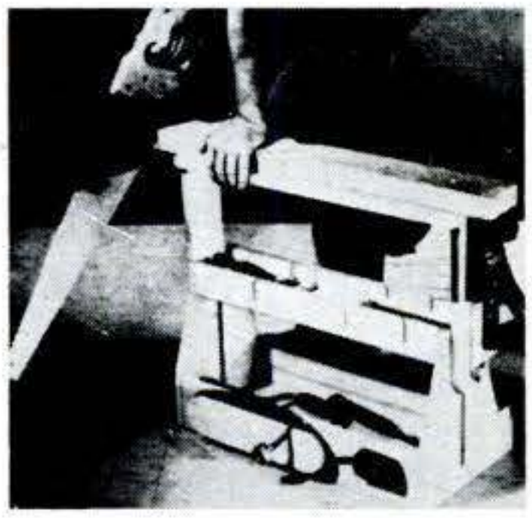

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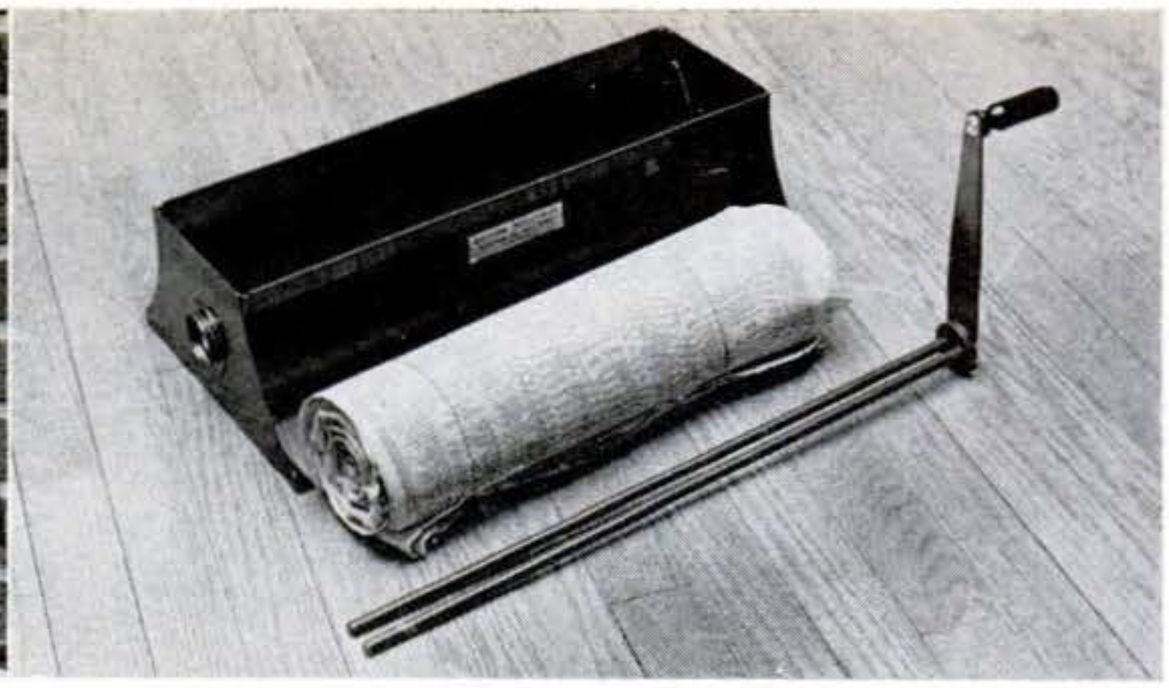
Paper logs burn like the real thing—minus the cracks and pops. As with wood logs, you need three of them to make a good fire.



Logger consists of a troughlike body with a removable crank to do the rolling. Typical log is 4½ inches in diameter.

Gadget works best fastened to a bench with the crank hanging over the end. It takes about a three-inch stack of paper per log.

Fireplace Logs: Now You Can Roll Your Own

You say you have a wood-burning fireplace, a huge stack of newspapers, but no cordwood? Now there's a gadget that can roll that stack of papers into a pile of paper logs—logs that burn like the real thing. It's called the Logger. To use it, you turn a crank and feed in newspaper a section at a time until you fill the trough with a 4½-inch log. Then just tie it with wire. Oil-treated, it'll burn fine.

The maker says to start each log with a pint of kerosene in the trough, but I like to pour the kero into the end of the log just before use. This lets you store logs without danger. The Logger is from Aviterra Corp., Box 34275, Bethesda, Md. 20034. Price is $14.90 (add $2 west of the Mississippi).—*A. J. Hand*

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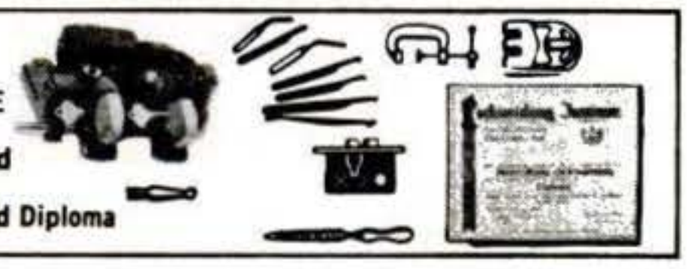

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[Continued from page 81]

to-metal contact (spring strips) are common; quarter-wave choke slots, sometimes filled with absorbing material, cancel microwave emissions. Lengths of rubber tube covered with metal braid are used, too.

The viewing window, which lets you monitor food cooking, is a metal screen perforated with holes. The holes are much smaller than microwave wavelengths and block radiation. Additionally, the new regulations require two safety interlocks on ovens to prevent accidental radiation when the door is opened. Some ovens use three interlocks; if one fails, the magnetron still shuts down.

The basic principle of microwave cooking—electromagnetically forcing the molecules within the food to vibrate and create heat—gives rise to many unique features. For example, paper, china, and many plastics are made of molecules that do not absorb microwave energy. Thus they make excellent cooking utensils. The food inside them gets hot, but they don't. (Even the interior of the oven stays cool, warming only indirectly and slightly as hot food radiates heat.)

Incidentally, some china and ceramic dishes do contain metal molecules and will get hot. Litton recommends that you try out the dishes you plan to use in the microwave oven by putting them in alone for 15 seconds. If they come out hot, don't cook in them. (The same company deliberately included ferrite molecules in its searing dishes so that they *will* get hot enough to brown steaks and other foods—more about that later.)

In general, metals, which reflect energy back through the waveguide to the magnetron, were forbidden in older ovens. But new tube and oven designs now enable you to use shallow metal containers—such as those for TV dinners. Such containers limit cooking to the top food surface.

Polarized molecules. The rate at which various foods cook depends on several factors: the ability to absorb microwaves, how well heat is retained, original food temperature, size, and shape. Food molecules vary in the rate at which they flip back and forth in the changing electric field—some are more "sluggish" than others. Forces restricting their vibration may be mechanical, as with ice or solid fats, or viscous, as with a thick syrup. Some molecules become polarized to a greater extent than others in the electric field.

Since water molecules are polarized even outside an electric field, the presence of moisture in foods greatly influences its heating rate in a microwave oven. Moisture is not necessary for microwave heating, but most foods contain water in varying amounts. This does not mean, though, that foods with more moisture heat faster. A pound of food with 50-percent moisture heats faster than another pound of food with 75-percent moisture. All microwave cooking requires close attention to *time*, since oven temperature is not a factor.

A food's *specific heat*—its ability to hold heat compared with water—also plays an important role. Water has a value of 1.0, but fats are about 0.5. This means that water requires twice as much heat as fat to increase one degree in temperature. Try to warm a frosted pastry in an oven, and the frosting—with a high fat and sugar content—melts very quickly.

Food penetration. With conventional cooking, heat must be conducted gradually from the food surface inside. Microwaves, however, are able to penetrate foods about one inch, greatly accelerating cooking time. But waves penetrating both sides of a steak or hamburger quickly cook the meat to the same degree throughout. Since the cavity is cool, however, the meat surface is cooler (through heat loss) than its interior. The resulting gray appearance of meats is not appealing to many.

That's where conventional ovens and recent microwave cooking developments come in. Owner's manuals for microwave ovens suggest you quickly sear or broil some meats in conventional ovens; complete the cooking in your microwave oven.

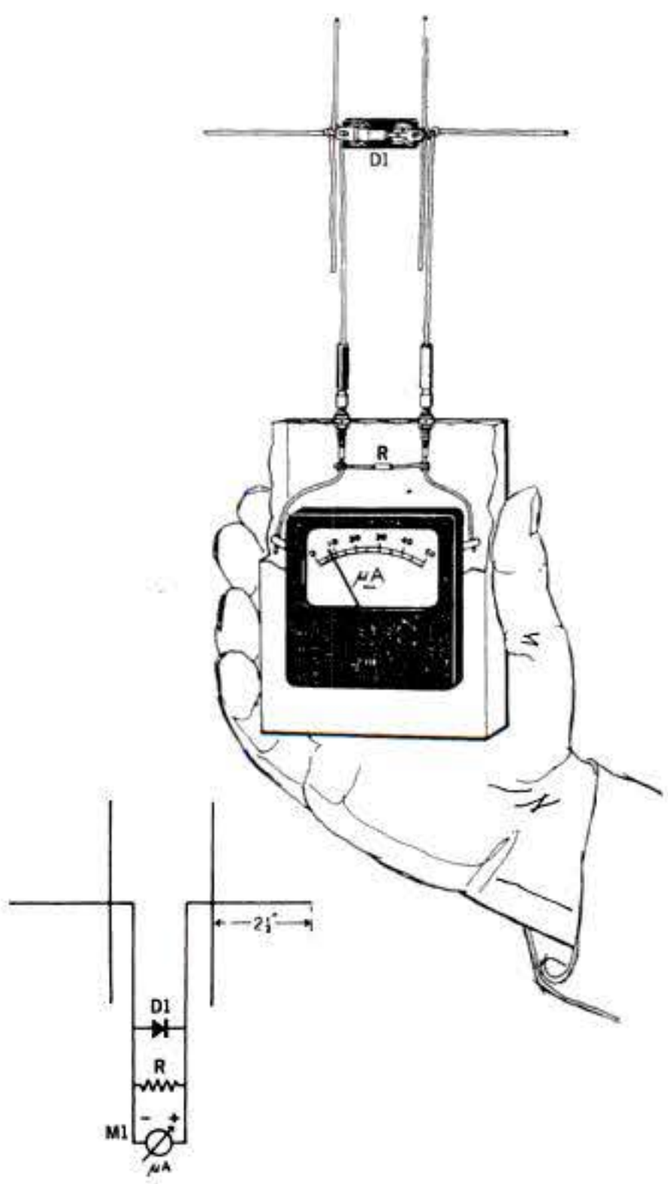
New cookware. The new metal-containing searing or burning cookware is an excellent solution to the problem. Because of their small size, however, large quantities of meats could be cooked better by other means. Litton's Micro-Browners are preheated by microwaves: four minutes if you're going to use them for meats, three minutes for pancakes, French toast, grilled sandwiches.

The ferrite-ceramic strips on the bottom of the cookware absorb energy and become hot, while blocking microwave penetration from the bottom of foods. Most meats require less than two minutes' cooking per side; bread items take about 30 seconds a side.

Browning ovens. Another solution to food browning is a resistance-heat-

Continued

Build a low-cost meter to spot microwave leakage



Microwave ovens are designed to keep radiation leakage within new federal guidelines. However, if the door or seal is damaged or gets worn, leakage may exceed standards. Spills and spatters between door flange and faceplate may also cause leakage. A neon lamp held near emission points will glow, a crude indicator. But this simple meter enables you to check levels. It's calibrated against a Litton 2450 meter like this:

Indication in μA	Radiation Intensity (mW/cm²)
6	0.5
12	1.0
20	2.5
30	5.0
40	7.0
50	10.0

Cut the dipole antenna from a coat hanger. Each element must be 2.5" long for 2450 mHz readings. The wires are bent and soldered to a fuse holder. Pinch one fuse clip to hold the narrow (cathode) end of D1 (1N23B). The HEP diode leads must be soldered. Energy received by the antenna is rectified by microwave-diode D1.

When taking a reading, put at least one cup of water in the oven. Hold the dipole antenna parallel against suspected leakage, but 2" from the oven surface. Rotate the dipole for maximum meter indication. Current federal standards call for a maximum radiation of 1 mW/cm² for new ovens; less than 5 mW/cm² after you buy it. Take readings 2" from any surface.—C. R. Lewart

PARTS LIST

D1--Microwave diode 1N23B or HEP R0700 silicon hot-carrier diode
R—220-ohm, ½-watt resistor
M1—0-50μA meter (Lafayette Radio Cat. No. 99P50429)
MISC—Case, fuse holder, wire

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Microwave-Oven Facts

[Continued]

ing element that emits infrared rays —like broilers in electric stoves. Because of their wattage, these elements must be used after microwave cooking is completed. (One exception is Thermador's MTR 12, which lets you use both functions simultaneously, but uses 240 volts.)

Sharp's new R-6600 has two timers. After the microwave timer shuts off the magnetron, the browning timer begins its cycle. I've found the searing cookware superior—and faster—than infrared for browning meats. Whole poultry, of course, can't be browned on searing cookware. But 5-10 minutes of infrared heat gives poultry a golden-brown appearance just like that of conventional cooking. As meat or poultry is browning, the interior finishes cooking.

Ovens with browning elements don't remain cool, of course, and generally better—and costlier—insulation is required to protect components. Heat buildup in a room is perceptible with the browning element on, but far less than with conventional ovens.

Self browning. Larger roasts and poultry—requiring 15 minutes or more —brown themselves in microwave ovens. This browning is aided by surface fats that reach temperatures above 212 degrees F.

There are problems with microwave cooking. For example, I observed some toughening of roasts. Eggs, cheese, and bread have similar problems, and Cornell University's Prof. Gertrude Armbruster explained why. The amount of heat energy applied to proteins in those foods is directly related to the formation of amino acid bonds. "The more bonds you form, the tougher the structure," she says. Manually cycling ovens on and off to prevent excessive heat buildup has achieved excellent results at Cornell.

Programed cooking. Armbruster believes programed on/off switches—like Litton's 402 for thawing—"could make a lot of things possible." The 402's 30-second on/off duration (a fixed program) does not seem suited to cooking, however.

Another problem encountered in microwave cooking is determining the correct timing for various quantities of food. Two items don't take twice as long as a single item, and timing can be critical. Many cookbooks provided with ovens are badly inadequate in this area. One that isn't, Litton's 168-page manual prepared with Pillsbury, is jammed with tables and microwave-based recipes. (A $6.95 check to Litton Industries at Cookbook, Box 707, Maple Plain, Minn., 55359, gets you one.) PS

Big Six: Multi-Purpose Tool

[Continued from page 18]

The Big Six is well made. Cast-iron frame and housings had been filled, sanded, and smoothly painted. All exposed metal was polished. The cross-slide ways showed the feathering of hand scraping. I took off all covers and guards to see inside. The insides were painted in finest machine-tool-building tradition. Anti-friction bearings were used at most locations. The spindle rides on tapered roller bearings that are adjustable for end play or wear.

Functions A-okay. They all worked smoothly and properly. With the two horses, there was the definite feeling of no-nonsense power. I particularly like the indexing two-position lathe toolpost that takes up to ¾" bits, and the husky, direct-adjusting accessory steady rest. The mill worked beautifully in all respects. The lathe tailstock, drill spindle, and mill spindle are all #3 Morse taper, so you can switch tools readily. In a trial, the beefily vised 12" blade hacksaw sliced squarely through a 2½"-diameter bar of heat-treated alloy steel in under 10 minutes.

Perhaps the most intriguing thing about this space saver is that you can have a setup going in three or four different places, and trot around sampling each one like a conductor directing an orchestra.

You can't have everything. Leastwise there are a few things I'd like to see. The lathe does not have power cross-feed, nor does the saddle have a lock to hold it in place while taking facing cuts. The latter could be added easily, however. It does not have quick-change feed/threading gears. The plain-change gears are changed in a gearbox at the right end of the lathe bed. Heavy use of the air compressor might be a problem. It has a 3.9-cfm compressor and a 17-psi, 2½-gallon tank.

The Multiple Six Machine is imported by Caldwell Industries, Box 170, Luling, Tex. The short-bed version (80" long, 28" between centers) sells for $3245, the long-bed option (90" long, 39⅜" B.C.) is $3595. These prices don't include shipping, but do include the basic six machine functions, motor, lathe faceplate, and wrenches. All available accessories (three and four-jaw chucks, steady rest, vertical milling head, dividing head and tailstock, drill chuck, flex shaft attachment, grinding-wheel holder, and bench vise) boost the total price for the long-bed machine to about $4800. Full machine specs and accessory prices are included in Caldwell's fascinating one-dollar general catalog. PS

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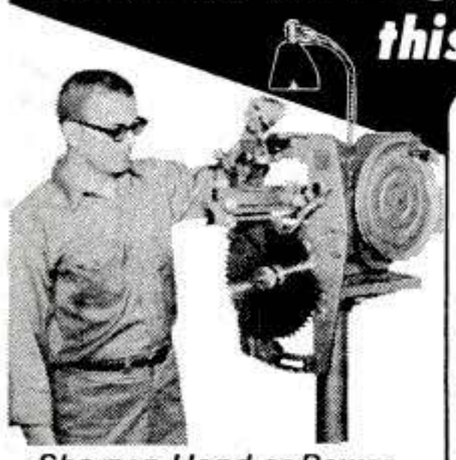

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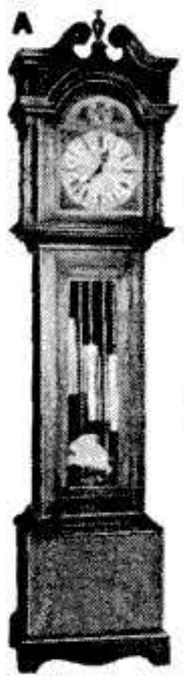

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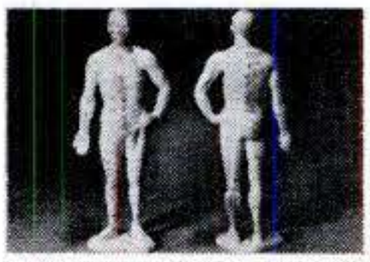

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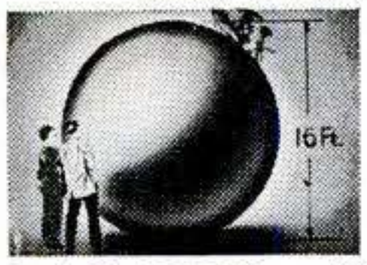

"Balls of fun" for kids, traffic stoppers for stores, terrific for amateur meteorologist. Create a neighborhood sensation. Great backyard fun. Exciting beach attraction. Amateur meteorologists use to measure cloud heights, wind speed and temp. Made of heavy duty neoprene. Inflate with vacuum cleaner or auto air hose; or locally available helium for high rise.

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Stock No. 60,632N ... **(16 Ft. diameter)** ... **$7.00 Ppd.**

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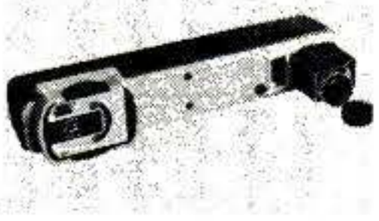

Direct reading up to 2 mi. Has 3 interchangeable pre-computed scales. In seconds, get exact fix, check distance & speed, correct compass. Gives 210' field of view at 500 yds; less than 1% error at 50 & 100 yds. 6 x 18X monocular detaches for sep use. Ideal for hunters, boaters, golfers, engrs., contractors, estimators. Weatherproof. 2-yr warranty.

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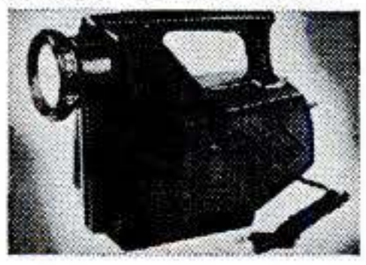

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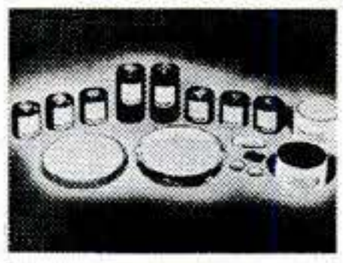

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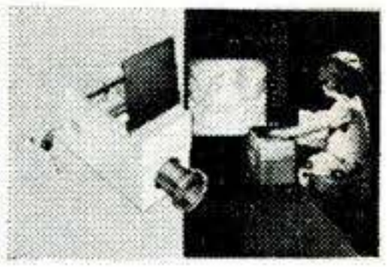

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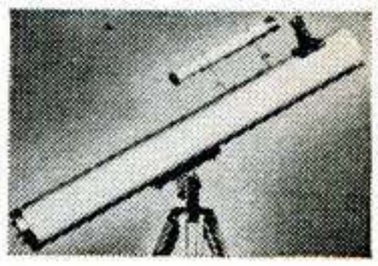

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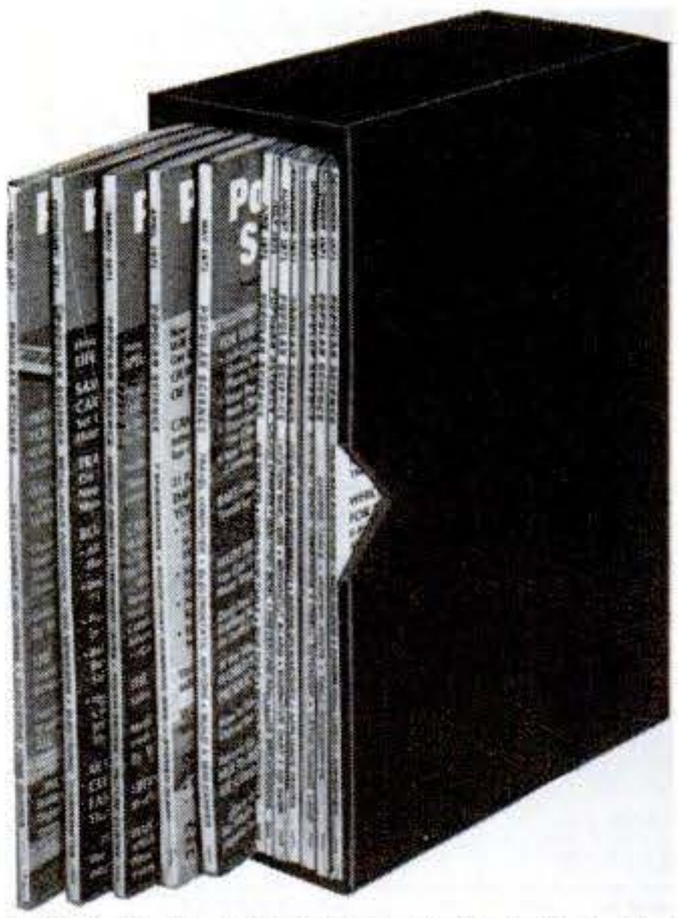

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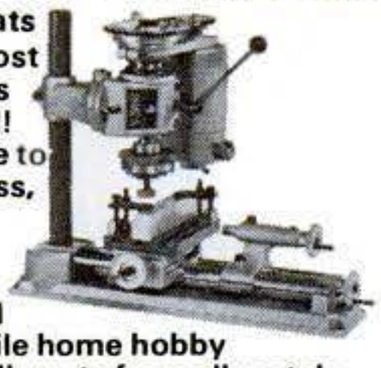

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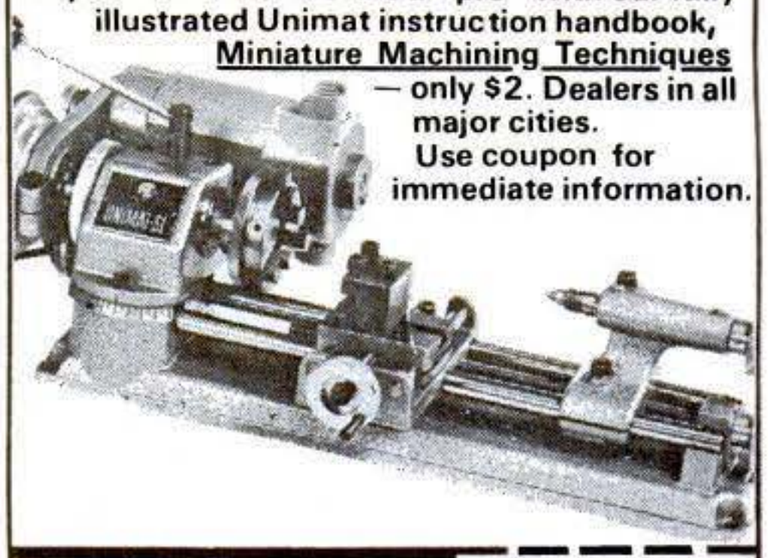

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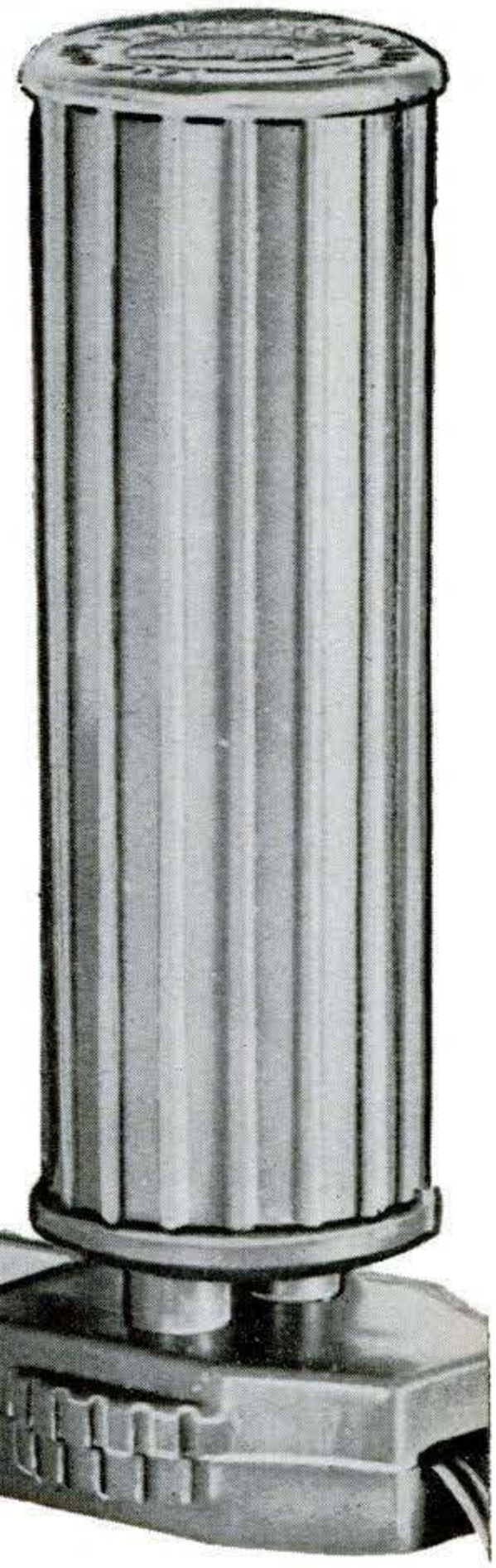

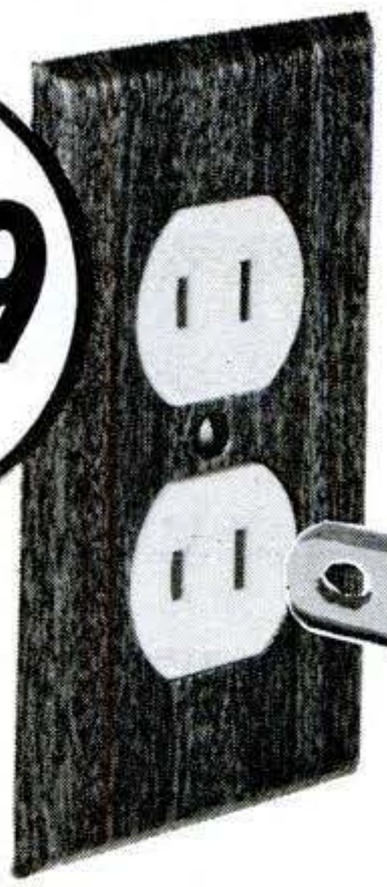

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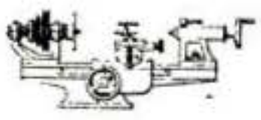

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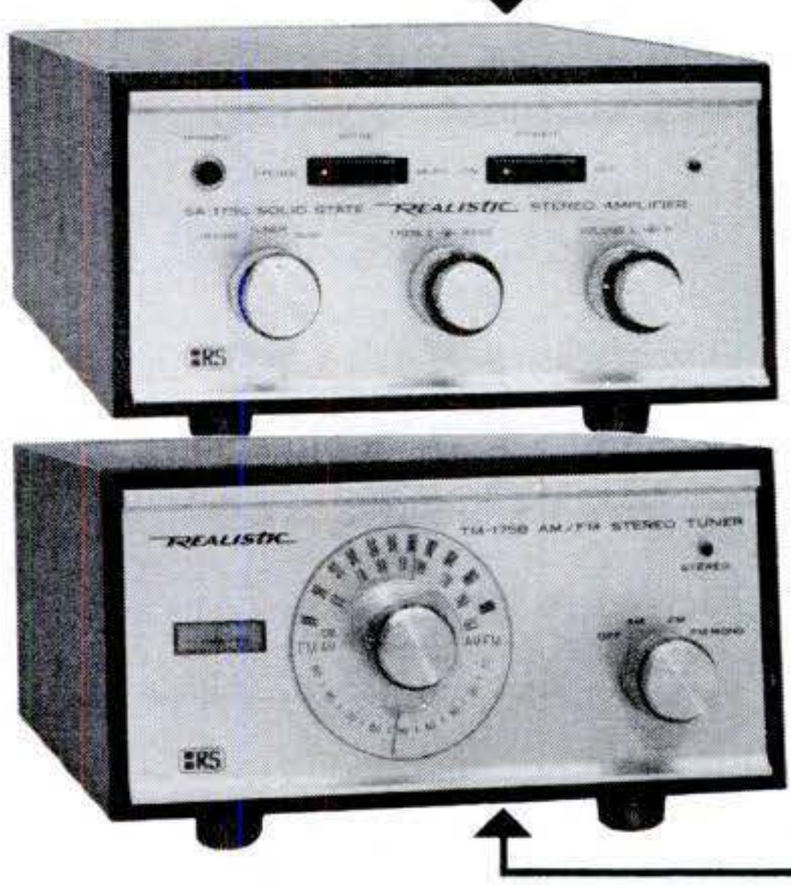

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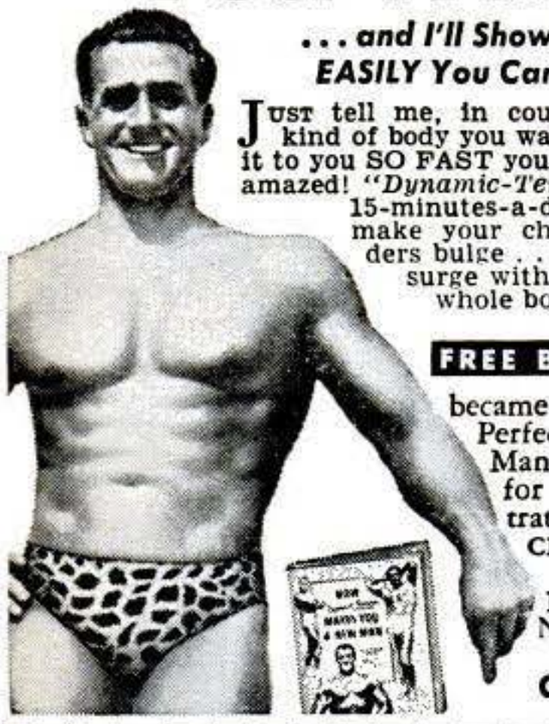

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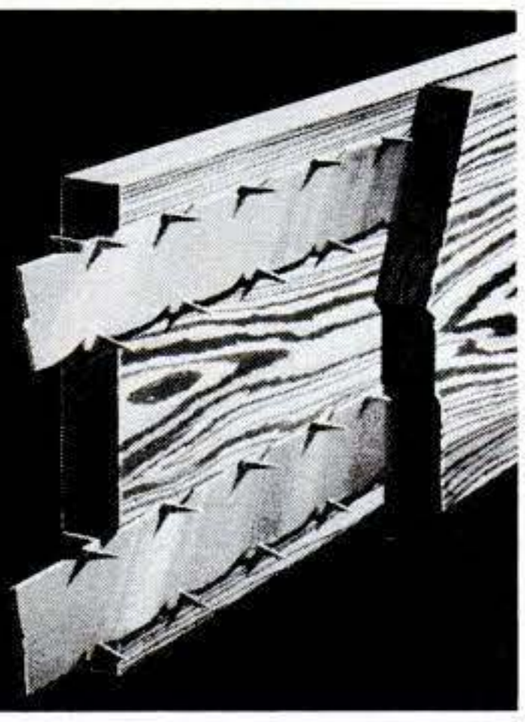

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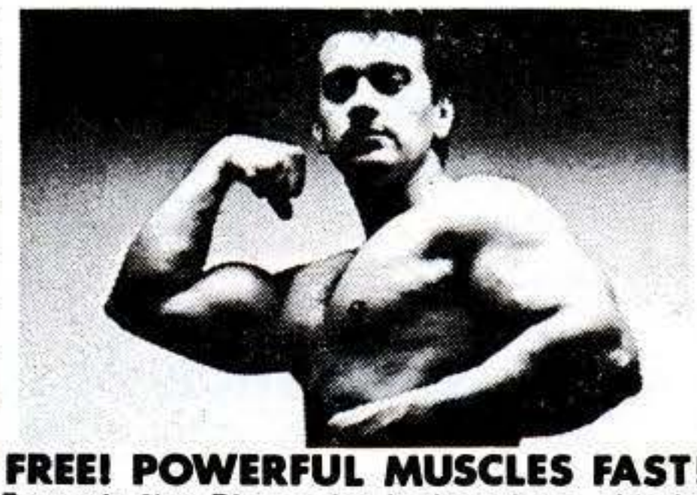

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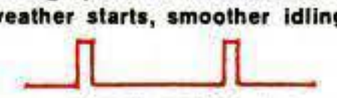

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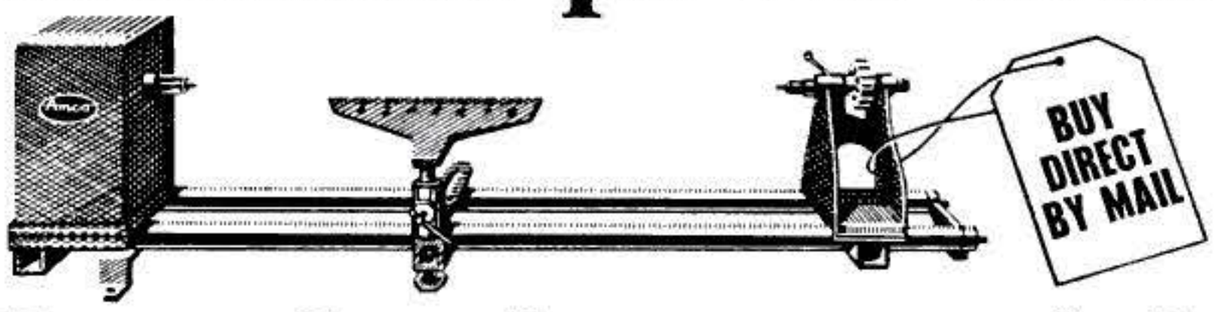

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We skipped the chrome to save you money . . . but we did not skip anything on performance. Actually, we skipped more than just chrome, we cut out every costly frill that wasn't absolutely needed.

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HERE'S HOW WE DO IT . . . First, we don't claim our tools should sell for five times the price! Just that our tools do the same job . . . with the same accuracy, ease and speed . . . and will last at least as long. AMT tools cost less to make and are sold direct. They are bona fide quality power tools used by serious amateurs and professionals alike and if sold in retail stores would be much higher in price. We use no magic, let's be specific:

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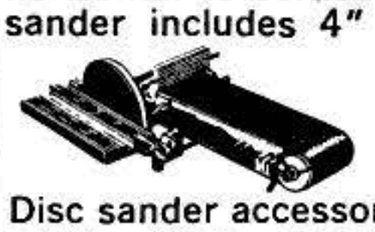

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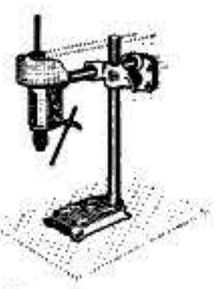

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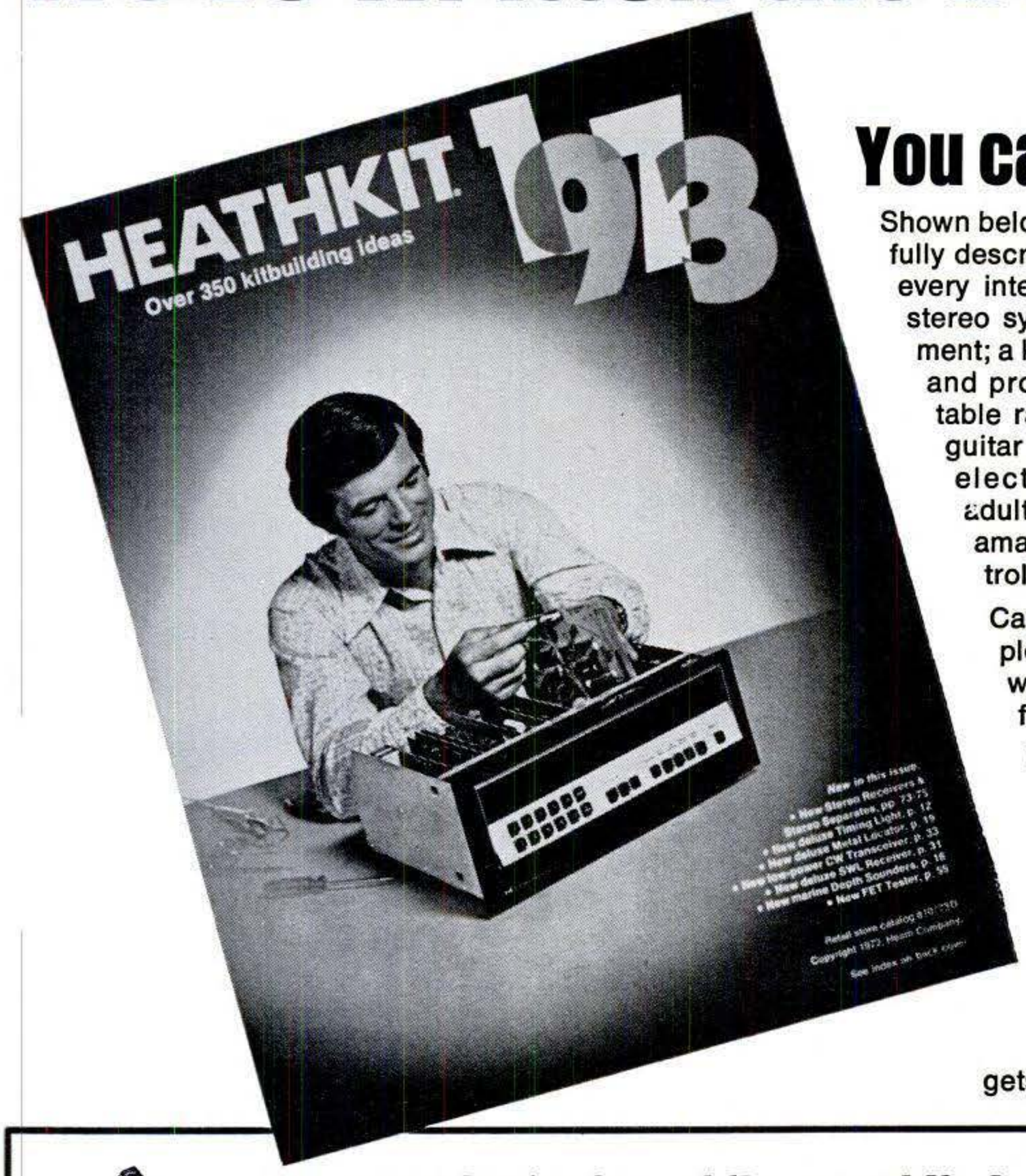

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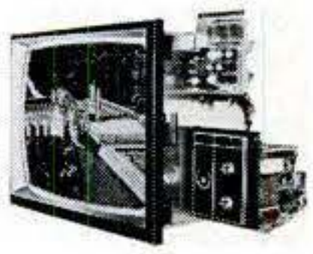

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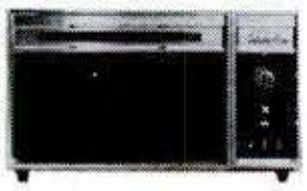

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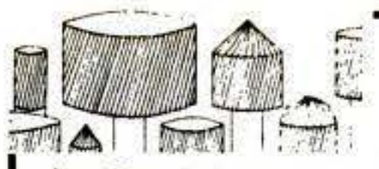

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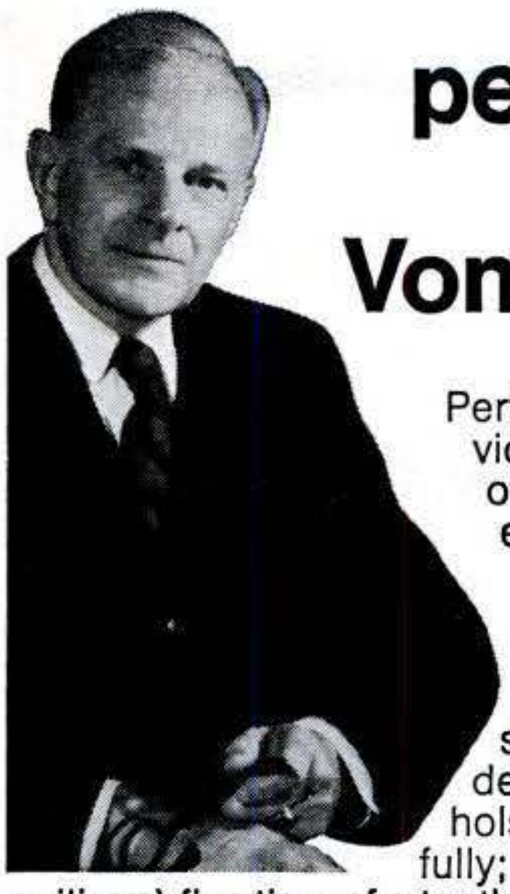

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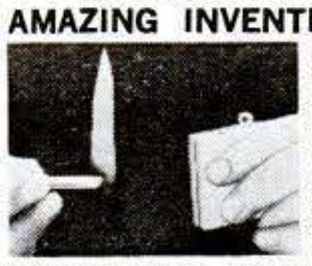

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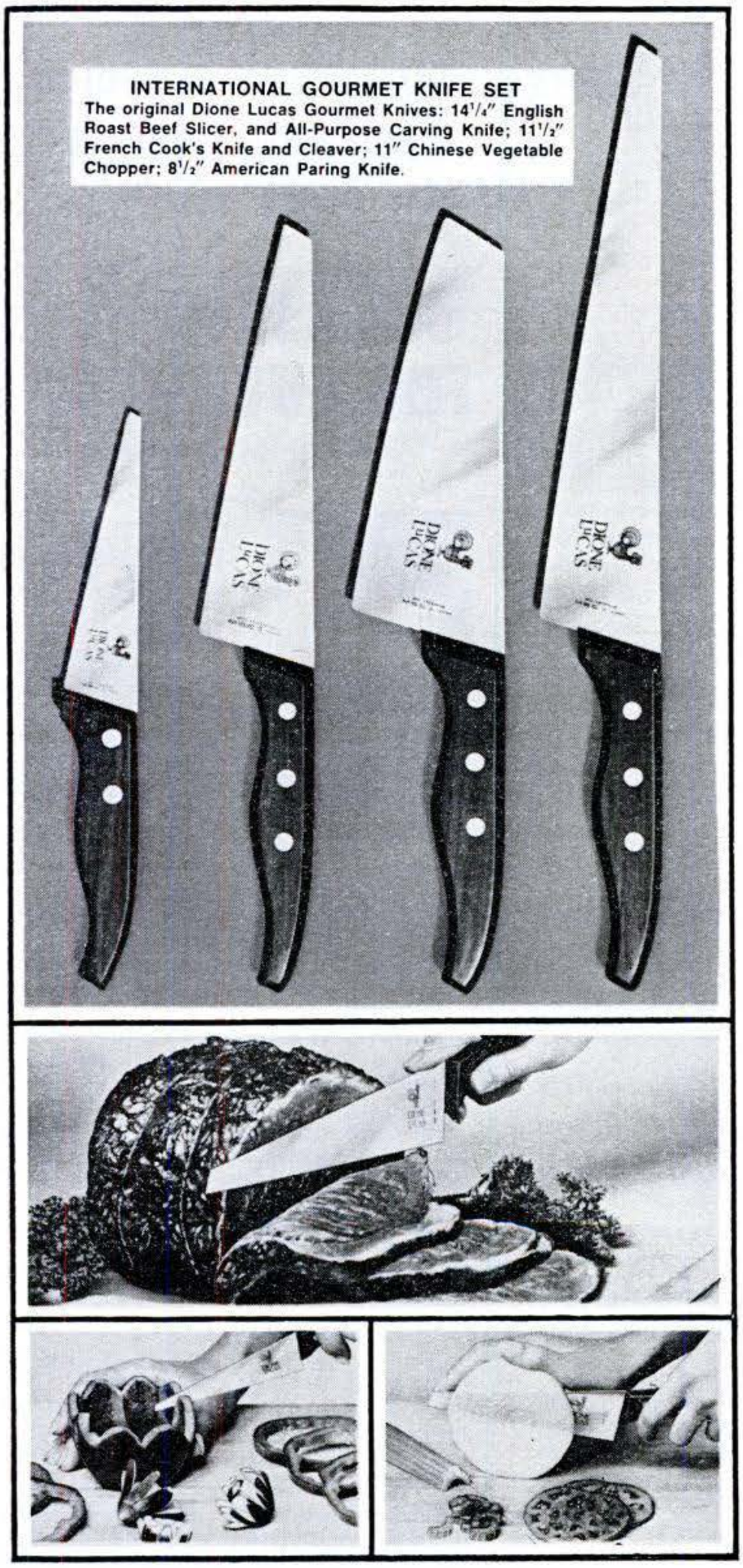

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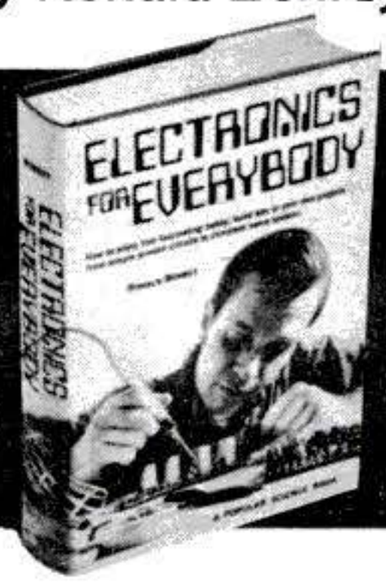

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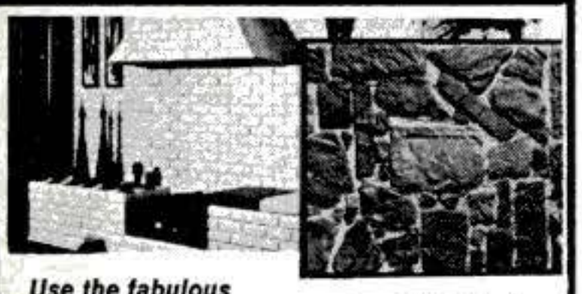

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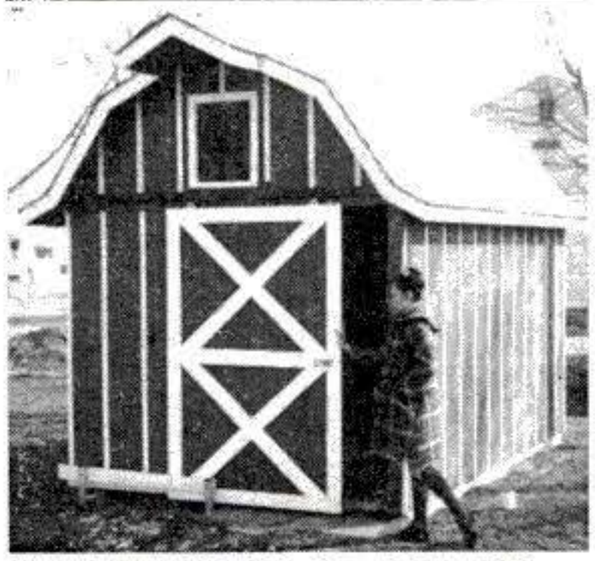

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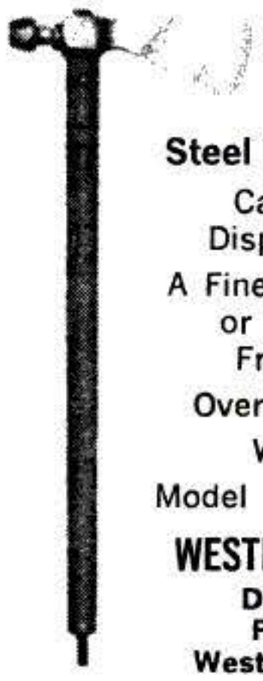

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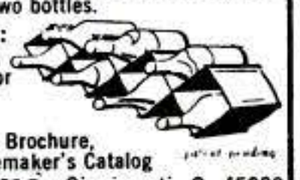

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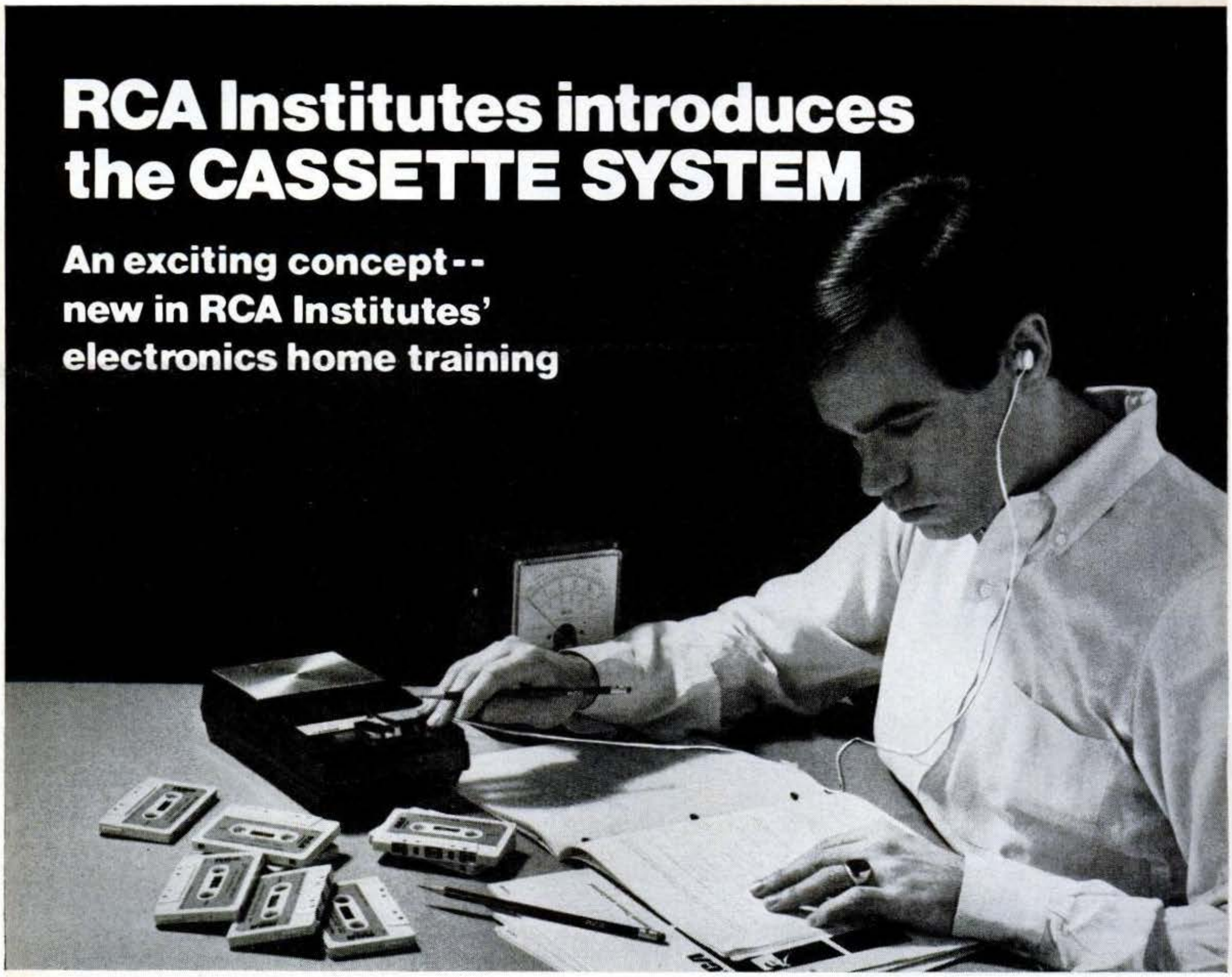

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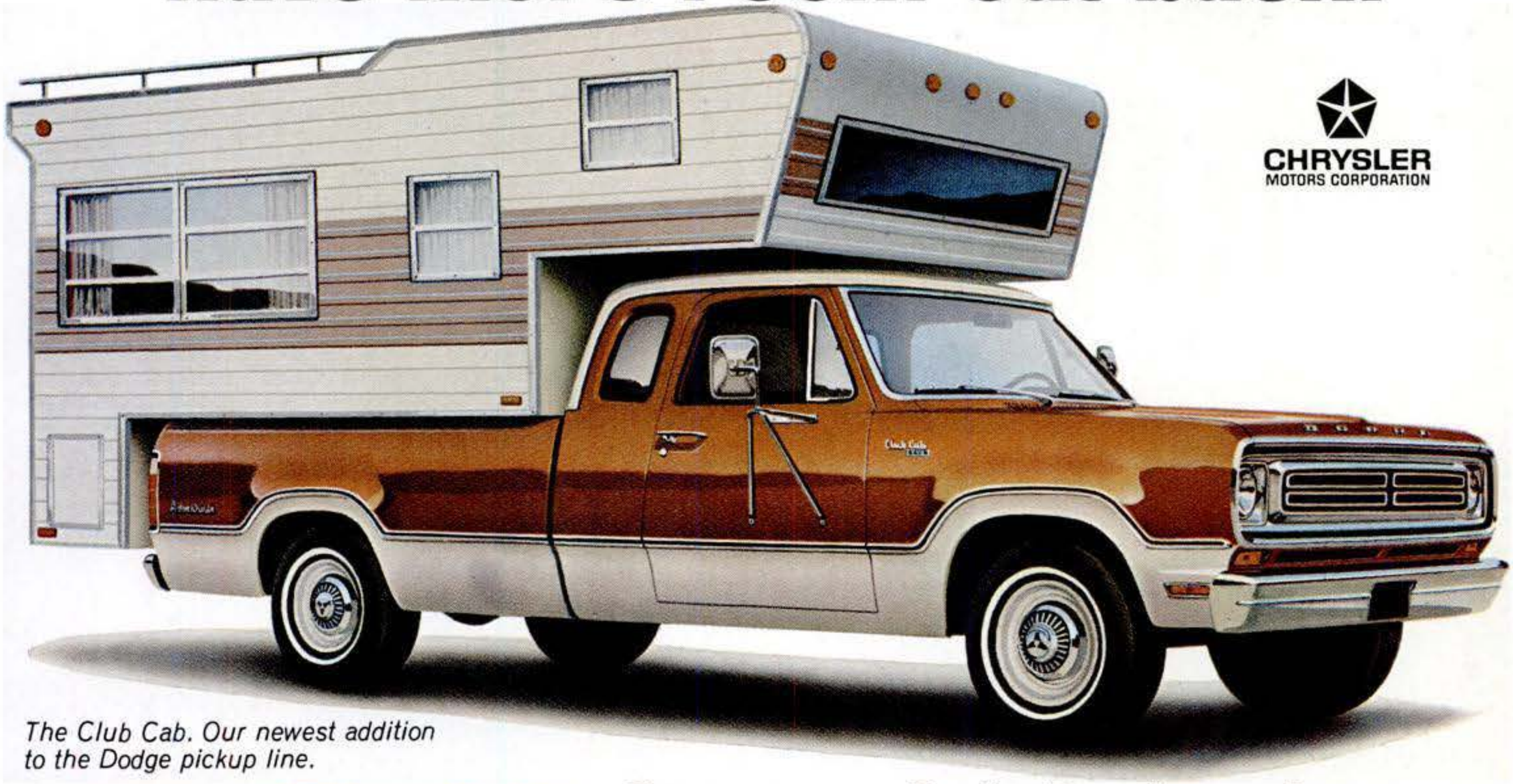

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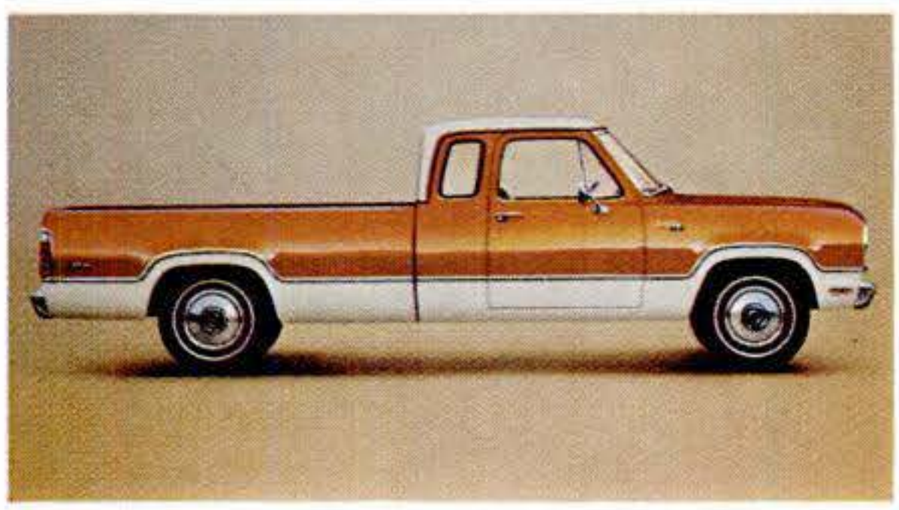

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